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## DISTURBANCE OF THE FUNCTION OF THE SALIVARY GLANDS

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Among the factors responsible for a dysfunction of the salivary glands little interest and scant attention have been given those which involve the nervous mechanism of these structures. Pathological alterations of gross or microscopic proportions are the obvious disturbing influences in the vast majority of patients with salivary gland disease, but in such individuals the dysfunction is usually limited to one or two glands and, therefore, seldom responsible for symptoms of impaired salivation. To be specific, a stone in Stenson's or Wharton's duct, a tumor of the parotid gland, or an inflammatory process in the submaxillary gland are not ordinarily the cause of a reduced salivary flow or noticeable alterations in the gland secretions.

The remaining salivary glands which are free from disease maintain a flow of saliva within limits more or less of normal physiologic action. When, however, some impairment to the nerve supply of the glands occurs, a widespread dysfunction of the salivary mechanism is the manifest reaction and dry mouth the symptom for which the patient seeks relief.

It is with this particular phase of dysfunction that we wish to deal in this discussion.

There are perhaps three classes of patients who come to the attention of the otolaryngologist with the symptom of a dry mouth. All complain of the absence of saliva, an annoying sticky feeling in the mouth and occasionally some difficulty in chewing and swallowing dry solid food. Inspection of the oral cavity promptly reveals the cause of the symptoms when the lesion is truly an organic one.

Frequently we are consulted by the patient for a dry mouth, with no apparent reason for this symptom. The mucous membranes are found moist, the salivary flow is prompt and adequate upon psychological stimulation or when pressure is applied to the glands, and the examiner is entirely at a loss to account for the patient's complaint on any basis other than a functional one.

This group of patients, the first to which we refer, comprises a goodly portion of those who daily seek professional advice. Not that they all complain of a dry mouth; they present various symptoms referable to the throat, nose and nasal accessory sinuses, and signs of nervous instability which clearly indicate a psychological state of the nature of a depression. The affliction is well known to all of us. The patient is tired, unable to work, complains of insomnia, is retarded mentally and has lost interest in living. Perhaps the chief symptom is a burning sensation in the mouth, or along the margin of the tongue. Hardly a day passes that we do not see some patient in our clinic who complains of this symptom. It is such a common disorder and so invariably unattended by any demonstrable organic lesion that the individual who presents it is categorically considered a candidate for a neuropsychiatric consultation.

These depressions are often self-limiting but in every instance they have serious potencies which call for the advice and care of the trained psychiatrist. They are worthy of sounder therapy than that which may be offered by the administration of one medicine after another or gained by frequent visits to different physicians who persistently fail to recognize the fundamental etiological factors and administer effective treatment. The resources and skill of the psychiatrist are needed when these circumstances exist and it is to him that we must look for the proper management of this group of patients.

It is the second class of patients with whom we have a deeper interest because they reveal an obvious organic lesion responsible for a dysfunction of the salivary glands and become, therefore, the

clientele of the otolaryngologist. These individuals actually have a dry mouth. The mucous membrane is parched, a wooden tongue blade drawn over the mucous membrane meets the resistance of a sticky surface, the tongue often appears desiccated with thin crusts upon its dorsum and psychological stimulation or pressure upon the glands reveals little or no saliva. Even when the patient is asked to suck a piece of lemon, salivation does not occur. This is the picture frequently seen in patients who have been subjected to deep x-ray therapy, but here the underlying pathological change is an actual disintegration of glandular tissue and its replacement by scar.

But the patients to whom we refer are those who demonstrate some physiological disturbance in the end-organs of the nerves supplying the salivary glands. One is able to classify them only in respect to their symptomatology because the etiology is usually obscure and pathological study impracticable. The disturbance is not an etiological entity, rather does it seem apparent that the causation may be any number of different factors and influences. Occupational hazards, such as exposure to organic dusts and zinc poisoning, seem to have been responsible in a few of our patients. Botulinus poisoning was the cause in one individual; however, no specific etiological factors have been demonstrated in the vast majority of persons who have consulted us on account of a dry mouth in which the nervous system has been at fault.

The pathological change responsible for this dysfunction cannot be revealed; nevertheless, the evidence derived from a therapeutic test clearly indicates that the secretory nerves are defective in this group of patients. In this connection we have frequently demonstrated prompt physiological action of the mechanism of salivation after the administration of pilocarpin. The drug shows a predilection for the end-organs of the secretory nerves and the response which it elicits is immutable proof of the presence of some disorder in the secretory fibers of the salivary glands. If administered in large enough doses at regular intervals and under proper conditions, pilocarpin is often a specific agent for the restoration of the normal function of salivation.

Pilocarpin hydrochloride or pilocarpin nitrate is taken orally in 10 mg. doses three times a day. It should be administered before meals in order to promote salivation when it is most needed. A practical point of great importance is the preparation of the patient for the maximum utilization and effectiveness of the drug. This embraces a therapeutic maxim based upon recent studies in physiology which deal with the transmission of nerve impulses.

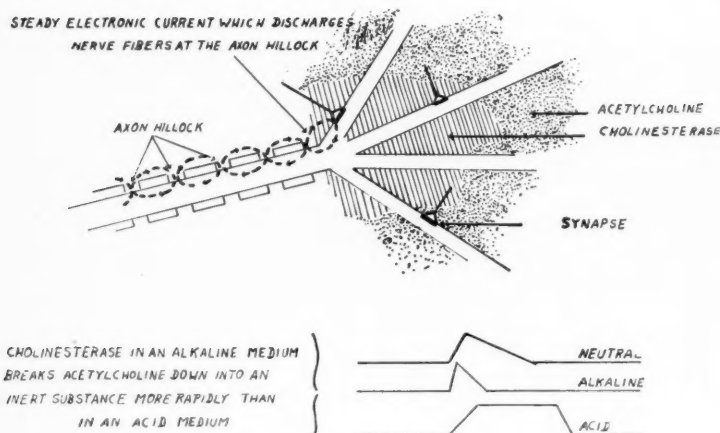


Fig. 1.

For example, it has been demonstrated in the laboratory of Dr. Robert Gesell that electrical energy is generated at the nerve synapse and that a steady electronic current is produced which discharges the nerve fiber at the axon hillock (Fig. 1). The impulse thus conveyed along the nerve is virtually an electrical one. It is created by a chemical agent, acetylcholine in the region of the nerve synapse, and this substance functions best in an acid medium. An enzyme, cholinesterase, which is everywhere associated with the acetylcholine breaks down acetylcholine into inert substances more rapidly in an alkaline medium than in an acid one. The practical point, therefore, and one of uncommon importance is to maintain an acid medium in the tissues in so far as it is compatible with life, if one hopes to obtain the maximum therapeutic action from the pilocarpin. In simple terms it may be stated that nerve conductivity is increased when the patient is in a mild state of acidosis. This can be demonstrated in the laboratory by using  $\text{CO}_2$  to augment temporarily the action of pilocarpin, and the maintenance of the maximum effect of the drug can be insured by the regular administration of the acid-forming salt, ammonium chloride. Thus it is recommended that the alkalis be restricted in the diet and that the patient be given 3 gm. of ammonium chloride with meals, three days "on" and two days "off" during the uninterrupted administration of the pilocarpin. In order to obtain



the maximum effect of the ammonium chloride it is essential to adhere to the program of omitting the drug for an interval of two or three days after a three-day period of its administration.

The final group of patients to which reference has already been made is of particular interest to the neurologist. They demonstrate a dysfunction of the salivary glands because of some organic lesion which irritates or interrupts the central pathways of the secretory nerves. Such lesions are frequently observed but rarely considered from the viewpoint of disturbed salivation because of the presence of more significant and conspicuous cranial nerve paralyses. Any lesion of the brain stem of sufficient proportions to irritate or cut off the nerve pathways to the salivary glands is certain to produce obvious paralysis of the cranial nerves. Although this group, therefore, may be only of academic interest, it is worth our time to consider these patients in the light of important neurological conditions which are associated with central lesions that cause a dysfunction of the salivary glands. Moreover, the paucity of otolaryngological literature on this subject and the apparent lack of interest on the part of writers in the field of neurology would seem to justify an attempt to organize available anatomical facts into some useful pattern and clarify if possible some of our conceptions of the physiology and pathological physiology of the central nerve pathways to the salivary glands.

As a basis for localizing some of the possible lesions of the nervous system which may alter salivary flow, certain pertinent neuron chains are presented. In reading the following discussion the figures should be consulted in close conjunction with the text.

Figure 2 is designed to review some of the neuron arcs generally accepted as being associated with the secretory activity of the salivary glands. Gustatory impulses entering the brain stem over sensory components of the facial, the glossopharyngeal and the vagus nerves, with their cells of origin in the respective sensory ganglia (G.G. and P.G.), terminate centrally in the dorsal visceral gray (N.S.) associated with fasciculus solitarius. Secondary neurons pass from this gray to nucleus salivatorius superior (S.S.) of the facial nerve and to nucleus salivatorius inferior (I.S.) of the glossopharyngeal nerve. In the *American Journal of Physiology* for 1942 (136:720-725), Magoun and Beaton discussed the position of these nuclei. Preganglionic fibers arising in the superior salivatory nucleus (S.S.) leave the brain stem in the facial root (VII) but then turn into chorda tympani (C.T.) which, after passing through the tympanic cavity and attaining a position under cover of the external pterygoid muscle, becomes as-

sociated with the lingual nerve. As the region of the submaxillary sympathetic ganglion (S.G.) is approached, some chorda tympani fibers arising from the superior salivatory nucleus turn into the ganglion to synapse with postganglionic neurons which distribute to the sublingual gland (SL.GL.). Other fibers arising from this nucleus pass on to the hilus and the main ducts of the submaxillary gland (S. GL.), where they synapse with the postganglionic neurons constituting Langley's ganglion (L). Such postganglionic neurons, which provide secretory and vasodilator fibers to the submaxillary and the sublingual glands,<sup>18</sup> end in fine terminal plexuses around the alveoli and between and on the gland cells. From nucleus salivatorius inferior (I.S.), preganglionic components of the glossopharyngeal nerve (IX) pass by way of the tympanic branch and the small superficial petrosal nerve to the otic ganglion (O.G.) for synapse with postganglionics supplying the parotid gland (P.GL.).

From the dorsal visceral gray of fasciculus solitarius (N.S.), short internuclear fibers enter the medial reticular gray (R.). From these reticular cells, neuraxons extend toward the midline to become descending components of the homolateral and the contralateral medial reticulospinal tracts (M.R.). At upper thoracic levels fibers of this component synapse with the preganglionic neurons of the lateral horn gray, the so-called intermediolateral column (I.C.). The fibers arising as neuraxons of such preganglionic neurons emerge with the ventral roots, turn off in white rami to the chain ganglia and ascend in the ganglionated sympathetic chain to synapse in the superior cervical ganglion (S.C.G.) with postganglionic neurons which, in turn, distribute to the various salivary glands (Figs. 2 and 3). Many physiologists<sup>18</sup> believe that these parasympathetic and sympathetic fibers supplying organs having a double innervation do not directly affect the metabolism of the elements supplied by them but operate by the release of hormonal substances (acetylcholine, usually but not invariably, for the parasympathetic, and an adrenalin-like substance for the sympathetic) at the nerve terminals.

To a very large extent physiologists have based their interpretations of the specific and interrelated functions of the parasympathetic and the sympathetic innervations of the salivary glands on the results presented by Heidenhain<sup>17</sup> in his classic study of these organs in dogs. It is beyond the scope of the present brief review to enter into a discussion of his theories about the presence of trophic fibers concerned with the formation of the organic substances of the saliva and of secretory fibers concerned with the secretion of inorganic salts and water. However, a very brief statement (for details, also see Howell<sup>18</sup>) of the functional interrelations of the two divisions of

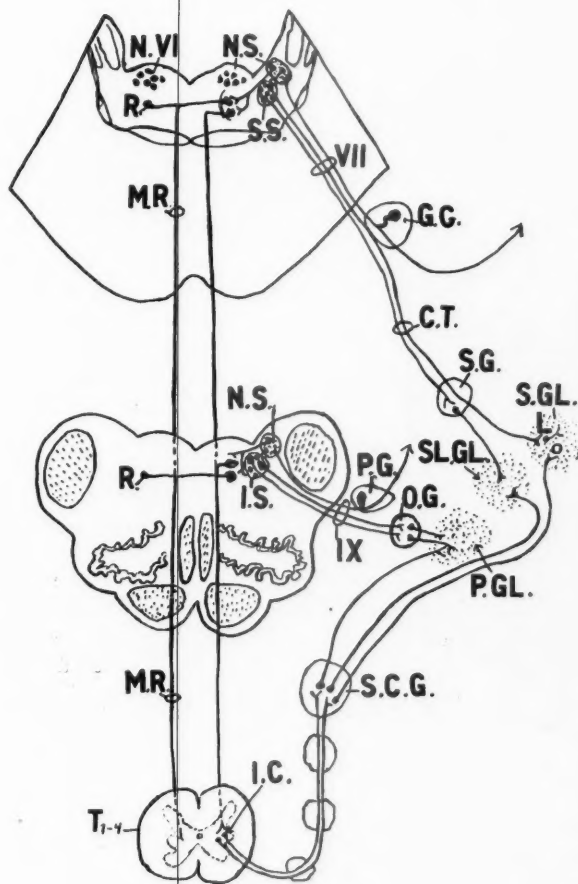


Fig. 2.—This diagram shows certain brain stem and spinal cord reflex paths associated with regulating the production of saliva. C.T., chorda tympani; G.G., geniculate ganglion; I.C., intermediolateral column; I.S., inferior salivatory nucleus; L., Langley's ganglion; M.R., medial reticulospinal tract (salivary component); N.S., dorsal visceral gray associated with fasciculus solitarius; N. VI., nucleus of abducens nerve; O.G., otic ganglion; P.G., petrosal ganglion; P.G.L., parotid gland; R., medial-reticular gray; S.C.G., superior cervical ganglion; S.G., submaxillary ganglion; S.G.L., submaxillary gland; S.S., superior salivatory nucleus; S.L.G.L., sublingual gland; T<sub>1-4</sub>, representative of 1-4 segments of thoracic cord; VII., facial nerve; IX., glossopharyngeal nerve.

the autonomic system in regulating the flow from the salivary glands may be pertinent here. When the chorda tympani is stimulated a thin, bitter, watery secretion is formed by the submaxillary and the sublingual glands and there is some vasodilatation. If the peripheral sympathetic chain be stimulated, a scanty, thick, mucoid secretion appears and there is a marked vasoconstriction of the vessels. Stimulation of only the parasympathetic fibers to the parotid gland gives a thin, watery secretion, stimulation of only the sympathetic chain produces no noticeable secretion, although it will affect vasoconstriction of the vessels. Simultaneous stimulation of both arcs results in a very different type of saliva, which contains a much larger amount of organic material. If, instead of excitation of the peripheral efferent chains, appropriate sensory stimuli (such as gustatory stimuli) be used, increased salivary flow from the submaxillary gland (and other salivary glands) will occur due to the stimulation of the appropriate parasympathetic and sympathetic arcs (Figs. 2 and 3), and some vasodilatation will result from stimulation of the parasympathetic arc. The vasoconstriction, which is a marked feature of the stimulation of the peripheral sympathetic arc, will not take place, probably because of the effect of those components of the medial reticulospinal tracts (Figs. 2 and 3) concerned with salivary flow which put the spinal cord centers under the regulatory control of the brain stem. Such inhibition or regulation of sympathetic discharges tends to produce a passive dilatation of the vessels concerned and provides a greater blood flow through the salivary glands during their secretory activity. The amount of blood supply is certainly one factor in determining such activity.

It is evident from the foregoing account that section of a glossopharyngeal or a facial nerve must interfere ultimately with the secretory activity of the appropriate salivary gland or glands, although for a time a gland, such as the submaxillary, may continue to secrete, forming the so-called paralytic saliva which disappears with the degeneration of the gland alveoli. Moreover, if only one nerve is sectioned (and this is usual, except under experimental conditions) the other salivary glands will compensate adequately for those which cannot function and a dry mouth will not result. Even if there is some slight inadequacy of salivary flow, due to a destruction of the facial nerve at its emergence, probably the inadequacy will not be noted in the presence of the graver disabilities which result from such a section (such as the homolateral flaccid paralysis of the muscles of facial expression with inability to close the eye completely on the side of the lesion and a loss of gustatory sensibility on the homolateral anterior two thirds of the tongue).

Central lesions at the level of the motor nuclei of the cranial nerves, or occurring during the intramedullary course of the roots, are rarely bilateral, and the dysfunction in salivation is compensated for easily. Such lesions are often accompanied by other more outstanding symptoms which tend to draw attention away from any slight decrease in salivary flow. Thus, hemorrhages in the superior salivatory nucleus might well involve the motor root of the facial nerve so that on the homolateral side there is a flaccid paralysis of the face with the loss of secretory impulses but without loss of gustatory sensibility, unless the sensory fibers or centers are involved. Consequently in the brain stem irritative lesions markedly increasing salivary flow and certainly destructive lesions of this region producing a dry mouth would necessarily be bilateral, and would be of sufficient extent to involve salivary centers of the lower pons and the upper medulla. Such lesions would probably be exceedingly rare clinically and difficult to produce in survival experiments. They would be accompanied by other motor and sensory deficiencies, which would easily determine the site of the lesions. Lesions of only the medial reticulospinal systems might not interfere with salivary flow because of the existence of other compensatory pathways from higher centers.

The superior and the inferior salivatory nuclei and certain specific portions of the reticular gray of the brain stem, on the one hand, and the intermediolateral columns of the spinal cord, on the other hand, are under the influence of higher centers, particularly of the hypothalamus, the thalamus, the lenticular nucleus and the cerebral cortex. The general pattern of connections which make such functional relations possible is easily understood in the light of numerous studies of the region. Some of these have been brought together in Vol. 20 of the Research Publications of the Association for Research in Nervous and Mental Disease dealing with the hypothalamus and in the book by Le Gros Clark, Beattie, Riddoch and Dott,<sup>23</sup> both of which should be consulted, but anatomical, experimental and clinical evidence for certain of the details is still meager. The diagram in Fig. 3 shows some of the pertinent connections. The hypothalamic relations will be considered first.

In Fig. 3 the medial preoptic area (P.) and certain major hypothalamic nuclei are diagrammed.<sup>16, 19, 23, 34, 35</sup> Neither the periventricular gray lining the ventricle nor the lateral hypothalamic area are illustrated in this figure, although the former region is labeled in Fig. 3A. Of these hypothalamic nuclei, the supraoptic nucleus, as many observers have shown, is related to the posterior lobe of the

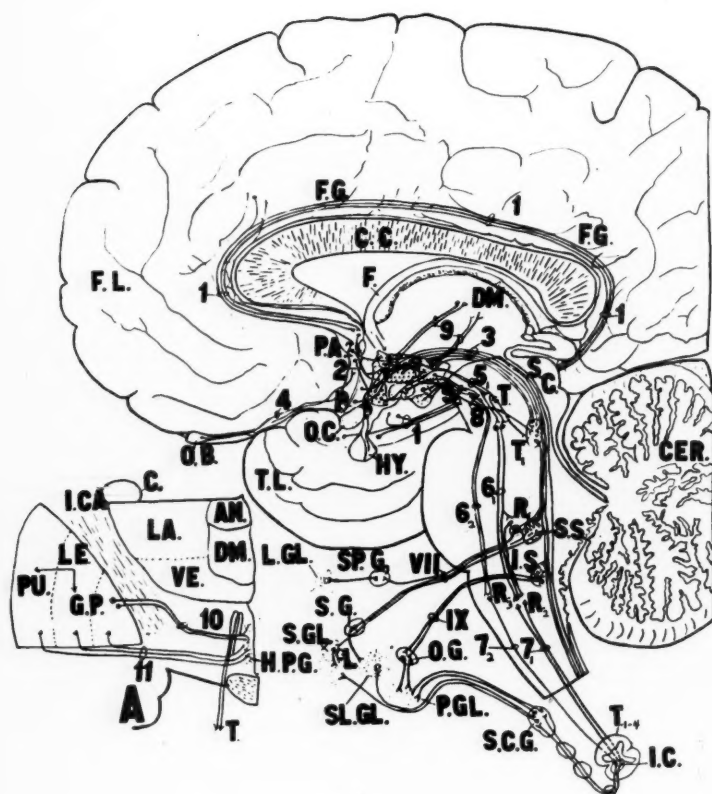


Fig. 3.

Fig. 3.—This diagram shows some of the nuclear regions and fiber connections of the central nervous system which have significance for salivary flow. The paths for discharge ( $5_1+6_1+7_1$ ) from the rostral hypothalamus are lateral to the midline but medial to the paths ( $5_2+6_2+7_2$ ) carrying impulses from the caudal hypothalamus. The hypothalamic nuclei are indicated in the diagram as follows: anterior hypothalamic area—solid black; dorsal nucleus—triangles; dorsomedial nucleus—crosses; mammillary body—outlined circles; paraventricular nucleus—wavy lines; posterior nucleus—small black dots; supramammillary nucleus—vertical lines; supraoptic nucleus—solid black; ventromedial hypothalamic nucleus—checks.

Fig. 3A.—This diagram shows certain relations of the lenticular nucleus (L.E.) to the hypothalamus and the tegmentum of the midbrain.

AN., anterior nucleus of thalamus; C., caudate nucleus; C.C., corpus callosum; CER., cerebellum; DM., dorsomedial nucleus of dorsal thalamus; F., fimbria-fornix; F.G., fornicate gyrus; F.L., frontal lobe; G.P., globus pallidus; H.P.G., hypothalamic periventricular gray; HY., hypophysis; I.C., intermedialateral column; I.CA., internal capsule; I.S., inferior salivatory nucleus; L., Langley's ganglion; LA., lateral nucleus of dorsal thalamus; L.E., lenticular nucleus; L. GL., lachrymal gland; O.B., olfactory bulb; O.C., optic chiasma; O.G., otic ganglion; P., medial preoptic area; P.A., parolfactory area; P.GL., parotid gland; PU., putamen; R<sub>1</sub>, reticular gray (pons); R<sub>2</sub>, reticular gray (medulla); R<sub>3</sub>, lateral reticular gray (medulla); S.C., superior colliculus; S.C.G., superior cervical ganglion; S.G., submaxillary ganglion; S.GL., submaxillary gland; S.L.GL., sublingual gland; SP.G., sphenopalatine ganglion; S.S., superior salivatory nucleus; T., midbrain tegmental gray; T<sub>1</sub>, dorsal tegmental nucleus; T<sub>1-4</sub>, representative of 1-4 segments of thoracic cord; T.L., temporal lobe; VE., ventral nucleus of dorsal thalamus; VII, facial nerve; IX, glossopharyngeal nerve; 1, cingulum; 2, medial forebrain bundle; 3, dorsal longitudinal fasciculus; 4, medial olfactory tract;  $5_1+5_2$ , hypothalamo-tegmental tracts;  $6_1+6_2$ , tegmento-reticular tracts;  $7_1+7_2$ , reticulo-spinal tracts;  $5_1+6_1+7_1$ , a discharge chain from the rostral hypothalamus;  $5_2+6_2+7_2$ , a discharge chain from the caudal hypothalamus; 8, mamillo-tegmental tract; 9, periventricular system interrelating hypothalamus and dorsal thalamus; 10, lenticular fasciculus; 11, ansa lenticularis.



hypophysis and need not receive further consideration here. (Various other subdivisions of the hypothalamus have been made, as for example, by Nicolesco and Nicolesco<sup>28</sup>).

Into this hypothalamic gray (Fig. 3) comes the medial forebrain bundle from the parolfactory area (P.A.) of the hemisphere. Such fibers carry impulses which have reached the parolfactory area from the olfactory bulb (O.B.) by way of the medial olfactory tract. In the parolfactory area these impulses have been modified by those from the olfacto-somatic association cortex, the fornicate gyrus (F.G.), through the cingulum (1) and possibly by those mediated over association fibers from the frontal lobe cortex. The medial forebrain bundle discharges such modified olfactory impulses to the medial preoptic area (P.A.) and to most of the hypothalamic nuclei, perhaps in largest number to the ventromedial hypothalamic nucleus. Also, to the preoptic and rostral hypothalamic areas, olfactory impulses from the olfactory bulb (O.B.) are relayed by way of the amygdaloid complex and from the hippocampus (olfactory projection cortex) through its fimbria-fornix system (F.). Ascending systems from the visceral centers of the cord<sup>1, 11, 12</sup> and from the gustatory centers of the brain stem (dorsal visceral gray of fasciculus solitarius) are believed to reach the hypothalamus. Various examples of afferents related to the autonomic nervous system have been described<sup>26</sup> but there is still much to be done on the specific central paths.

From the hypothalamus there are several major discharge paths (Fig. 3). From the mammillary body, fascicles pass to the dorsal tegmental ( $T_1$ ) and the interpeduncular nuclei. The former nucleus also receives impulses from the preoptic area (P.), from the periventricular hypothalamic gray (H.P.G.) and from nearly all the medial group of hypothalamic nuclei (with the exception of the supraoptic nucleus and perhaps the ventromedial hypothalamic nucleus) by way of the phylogenetically very old<sup>10</sup> dorsal longitudinal fasciculus (3). From its preoptic and hypothalamic origin, the dorsal longitudinal fasciculus<sup>1, 22, 31, 36</sup> swings caudalward close to the ventricular surface until lower inferior collicular levels are attained. Here the bundle comes into relationship with, and many of its fibers terminate in, the dorsal tegmental nucleus, as did those of the mammillo-tegmental tract (8). However, a considerable number of the fibers constituting the dorsal longitudinal fasciculus, augmented by those arising in the dorsal tegmental nucleus, continues caudalward in a sub-ventricular position to the uppermost levels of the spinal cord, distributing in course to motor centers and parasympathetic nuclei of the brain stem. Among such parasympathetic centers are the superior and the inferior salivatory nuclei.

Further discharge paths from the hypothalamus are provided by the so-called hypothalamo-tegmental, tegmento-reticular and reticulospinal tracts (see paths  $\delta_1$ ,  $\delta_2$ ,  $6_1$ ,  $6_2$ ,  $7_1$  and  $7_2$  in Fig. 3). Of the bundles of this type, those from the caudal hypothalamic regions ( $\delta_2$ ,  $6_2$  and  $7_2$ ) are more readily traced and their existence has been predicated for some time.<sup>1</sup> There has accumulated of recent years, through the excellent experimental work of Beattie and his collaborators, of Ranson and his associates and of others, a considerable body of evidence, the consensus of which indicates that descending paths from both rostral and caudal hypothalamic areas course through the caudal part of the lateral hypothalamic field.<sup>4-6, 9, 20, 25, 33</sup> Stimulation of points at various levels of the nervous system of the cat, from rostral diencephalic to medulla levels, gave a rise in blood pressure and provided evidence for descending hypothalamo-tegmento-(reticulo-) spinal paths.<sup>25, 27, 37</sup> This work<sup>38</sup> was supplemented by a study in which the lesions were so placed as to give some clues as to the position of these descending systems. The results indicated that in the midbrain such descending paths were located in the central region and more laterally placed portions of the tegmentum but that they shifted laterally in the pons and especially in the medulla. They are in the ventrolateral funiculus of the cervical cord.<sup>25</sup> The results obtained by List and Peet<sup>24</sup> in their study of a series of cases in which sweating was abolished for certain areas are in general agreement with the pattern obtained by Ranson and his associates. Many other observers<sup>5, 6, 39</sup> have emphasized these descending systems and the importance of the hypothalamus in temperature control in man.<sup>13, 41</sup> Recently, Beaton, Leininger and McKinley<sup>3</sup> have shown that these descending systems from the hypothalamus, both those related to heat-conservation and to heat-loss, can be broken up by experimental methods into separate components with distinct functional significance: that is, some of them are related to sweating and respiratory changes, some to shivering, some to somatic and autonomic functions. They stated that "apparently these different activities are mediated by distinct anatomical connections rather than by collaterals from single pathways". They regarded the descending hypothalamo-tegmental tracts as of more importance than the periventricular system in the discharge of the hypothalamus. These hypothalamo-tegmento-(reticulo-) spinal systems still need careful microscopic analysis in normal, experimental and pathological material. In connection with the study of midbrain connections, Crosby and Woodburne have partially completed such an analysis.

The observations of Ranson<sup>32</sup> indicated that lesions in the caudal part of the hypothalamus interfered, in subprimates and primates,

with ability to regulate against cold. Such regulation is accomplished in part by contraction of certain but not all superficial vessels. The blood supply of the salivary glands is provided for by branches of vessels supplying the face. Consequently the posterior hypothalamic areas are concerned also with regulating the amount of blood supplied to the salivary glands. Irritative lesions or stimulation of this portion of the hypothalamus should result in a decreased blood circulation through the glands and consequently a decreased salivary flow. The discharge is made through the appropriate hypothalamo-tegmento-spinal fascicles which run caudalward and lateralward through the tegmentum (T.) probably in specific position<sup>3</sup> and, in the medulla, approach the lateral reticular gray (R<sub>2</sub>) where they may undergo some synapse. They then pass into the cord occupying a ventrolateral position until their termination in relation to efferent neurons.

Irritative lesions (particularly bilateral lesions) of the preoptic and anterior hypothalamic regions appear to increase the secretory activity of the salivary glands. In a patient who showed diencephalic autonomic epilepsy, Penfield<sup>29</sup> found a tumor suspended in the inter-ventricular foramen but free to move so that it pressed somewhat intermittently on the subventricular gray around and ventral to the anterior commissure. This gray included the preoptic and the most rostral hypothalamic areas. Among other symptoms was an increased salivary flow. Since sweating also occurred in this syndrome and since this region is known to be a center for regulation against heat,<sup>32</sup> the tumor was obviously having an irritative effect upon the underlying preoptic and rostral hypothalamic gray. From this region the impulses were shunted along the dorsal longitudinal fasciculus (3 Fig. 3) to the superior and the inferior salivatory nuclei. These nuclei distribute secretory (and some vasodilator fibers) to the salivary glands.

The rostral hypothalamic nuclei discharge by means of internuclear fibers to the posterior hypothalamus, regulating and even preventing the discharge of the latter region, which functions to decrease salivary blood supply. There is also some evidence that there are impulses of an inhibitory character which pass caudally from the preoptic and the hypothalamic regions through the lateral hypothalamic area to the brain stem and the spinal cord.

A discharge path (5, 6, and 7, Fig. 3) to the cord from the preoptic and rostral hypothalamic areas would be in line with that predicated by Ranson and his associates.<sup>9, 25, 32, 33</sup> They found these rostral regions concerned with regulation to heat, as evidenced by sweating, panting and vasodilatation, and believed that a discharge

path ran caudalward from them through the lateral hypothalamic area to the appropriate spinal centers. This has been documented by various observers—in greatest detail, as to location of pathways by Keller,<sup>21</sup> Blair and Keller,<sup>7</sup> and especially by Beaton, Leininger and McKinley.<sup>3</sup> Furthermore, some of the fibers of this descending hypothalamo-tegmento-reticular tract may come into relation with those components of the medial reticulospinal tracts which are related to salivary flow (M.R., Fig. 2). Stimulation of these medial reticulospinal tracts would inhibit the flow of impulses over the sympathetic arcs supplying the salivary blood vessels and result in a passive dilatation of the vessels to the glands, and so an increased circulation of blood through the glands which would further salivary flow.

Destructive lesions involving bilaterally the preoptic and the rostral hypothalamic regions would decrease the amount of saliva produced, partly at least because they would involve destruction of the olfactory paths. Such olfactory stimuli are evidently a major factor in producing salivary flow. It is to be noted (Fig. 3) that these olfactory bundles to the preoptic area and the rostral hypothalamus could be completely destroyed without interfering with olfactory consciousness.

The dorsal thalamus—most particularly its anterior (AN., Fig. 3A) and dorsomedial (DM., Figs. 3 and 3A) nuclei—is intimately interrelated with the hypothalamus, not only by the well known Vic d'Azyr tract or the mammillo-thalamic system between the mammillary body and the anterior thalamic nuclei, but also by way of periventricular fibers (9) between the dorsomedial nucleus of the thalamus and the hypothalamic areas. Such periventricular bundles appear to be both afferent and efferent with respect to the hypothalamus.<sup>8</sup> Since the anterior and the dorsomedial nuclei are connected respectively with the cingulate gyrus and the frontal cortex, obviously pathways by which the hypothalamus and certain cortical areas may be interconnected are thus provided. The significance of such cortical pathways will be considered later. Beattie<sup>6</sup> regarded the thalamus as exerting excitatory influences over the hypothalamus.

The lenticular nucleus (LE., Fig. 3A) of each hemisphere discharges impulses, through the lenticular fasciculus and ansa lenticularis, into hypothalamic periventricular gray and into the midbrain tegmentum (Fig. 3A). Such impulses on reaching the midbrain may relay with tegmentobulbar or tegmentospinal tracts.

In some cases showing Parkinson's syndrome or following epidemic encephalitis,<sup>40</sup> sialorrhea is a part of the clinical picture. Its appearance is due probably to some malfunctioning of the lenticular

nuclei of the cerebral hemispheres. However, opinions differ as to whether the characteristic symptoms are release phenomena appearing as the result of bilateral degeneration of lenticular neurons and so of efferent lenticular tracts, or irritation phenomena produced by the still functioning lenticular cells, which are being stimulated through toxic substances produced by the degenerating neurons. In addition to the recently much described nigro-pallidal tract and the anterior thalamic peduncle from the basal ganglia to the dorsomedial nucleus of the dorsal thalamus, each lenticular nucleus has other connections. It gives rise to several well-developed descending systems (Fig. 3A) which have been described in some detail by many earlier as well as some recent observers (for a review of some of this literature, see Ariëns Kappers, Huber and Crosby<sup>1</sup>). For the present purposes only such connections of these nuclei as may have significance for salivary flow need be mentioned. At least two of these descending paths—the lenticular fasciculus of Forel (10) and the ansa lenticularis (11)—give off some fibers to the periventricular gray (H.P.G.) of the caudal preoptic and rostral hypothalamic regions and distribute rather widely to the tegmental gray of the midbrain. The fiber distribution to the hypothalamic area, though rather meager, may relate itself to neurons distributing to the parasympathetic salivatory nuclei—the superior (S.S.) and the inferior (I.S.) salivatory nuclei—by way of the dorsal longitudinal fasciculus. The paths passing to the tegmentum, in so far as related to salivary flow, probably also connect with tegmento-reticular and reticulo-spinal descending paths so related as to regulate the blood supply to the salivary glands.

Certain cortical areas also influence salivary flow. As was stated previously, the hippocampus discharges to most of the hypothalamic nuclei through the fimbria-fornix system (F.). From many of these nuclei connections are made, through the dorsal longitudinal fasciculus (3), to the parasympathetic salivatory centers (I.S. and S.S.). The pattern arrangement within the olfactory areas of the hemisphere, by which it is possible to recognize different odors, is as yet practically unknown. Such an analysis is necessary before it is possible to evaluate the significance of the terminal spread of the fornix system within the hypothalamus. Destruction of the olfactory bulb, of the hippocampal cortex, or its discharge path, the fimbria-fornix system, will definitely interfere with increased salivary flow during eating, since it will cut off from consciousness the odors arising from many foods. It should be borne in mind, however, that a salivary response may occur in cases of complete anosmia by use within the nasal cavity of some substance such as citral, a response due presumably to stimulation of the

trigeminal nerve (olfactory-parotid response of Elsberg, Spotnitz and Strongin<sup>14</sup>).

The medial forebrain bundle (2, Fig. 3) brings into the hypothalamus some impulses reaching it by fascicles of the cingulum (1) from the fornicate gyrus (F.G.), an olfacto-association cortex, and others from the neighboring frontal cortex by short fibers. There is a fair amount of evidence that the frontal cortex must be connected with the hypothalamus and that such a cortico-hypothalamic system regulates the flow of impulses through the hypothalamus so that psychic states are manifested by certain reactions brought out through sympathetic and parasympathetic responses, such as sweating during excitement or a dry throat brought about by embarrassment or fear. Further information is necessary regarding the course, origin and termination of the cortico-hypothalamic systems before they can be evaluated adequately. Some of the connections from cortex to hypothalamus (and also from hypothalamus to cortex) are certainly by way of the dorsomedial nucleus of the dorsal thalamus. Stimulation of (and presumably irritative lesions in) the lower part of the sensory-motor region of the cortex, in the portion sometimes called the masticatory field<sup>20</sup> will result in increased salivary flow. Numerous clinical papers<sup>2</sup> deal with the interrelation between psychic phenomena in man which are presumably cortical and the attendant outward emotional manifestations in which the hypothalamus plays a part. Pathological conditions of the frontal cortex, or other cortical areas, may lead to some general changes such as the vasodilatation following frontal lobotomy<sup>15</sup> which should ultimately affect salivary flow. Certainly their results indicate some regulating influence of these regions over the sympathetic and parasympathetic systems.

It should be stressed that the various "centers", such as the posterior hypothalamic area or the anterior hypothalamic and preoptic regions, function as regulators of salivary secretion by virtue of their position in specific neuron arcs related to salivary function. Such "centers" are afferent or efferent in character in this chain by virtue of the polarization of the arc. It seems improbable that such an afferent or efferent character would be interchangeable once it had been established. However, within the efferent field, for example, the observable functional significance of the center is determined by the connections of its terminal neurons. These are components of peripheral nerves and may carry motor fibers to striated or smooth muscle or secretory or excretory fibers to the glands. If the peripheral innervation were changed, the functions of the appropriate "center" within the central nervous system would be altered. Beattie<sup>5</sup> found that stimulation of the rostral hypothalamus accelerated peristaltic action of the



stomach. Section of the vagus did away with this reaction, but if, then, the central stump of the vagus nerve was allowed to regenerate in relation to the muscles of the diaphragm, stimulation of the rostral portion of the hypothalamus produced contraction of the diaphragm. There is no question in the authors' minds that if the chorda tympani were cut as it lies between the pterygoid muscles (a difficult feat to carry out) and the central stump permitted to regenerate in connection with muscle fibers, that contraction of these muscle fibers, not increased salivary flow, would result from stimulation of the pre-optic and the most rostral hypothalamic regions. The specificity of a region at any time is determined by its position in a complete and functioning neuron arc, and is actually impressed on it at the passage of the nerve impulse.

Finally many subcortical centers are under the influence of cortical regions, and these regions in turn are so interrelated that the impulses passing from them are the results of complicated associations, which vary in content in different individuals and color the individual responses. Those regulating salivary flow are no exception to this rule, and clinical pictures showing increased or decreased amounts of saliva, which might be explained fully on the basis of hypothalamic or tegmental or other subcortical lesions may, actually, be resultants of excitatory or inhibitory cortical impulses.

To recapitulate:

- 1) A dry mouth will not be produced by the dysfunction of a single salivary gland, by the peripheral section of secretory fibers of the facial or the glossopharyngeal nerve, nor by the destruction centrally of the superior or inferior salivatory nuclei, which give rise to such secretory fibers, since the other main salivary glands (and the smaller glands of the oral cavity) will compensate adequately.

- 2) In order to produce dry mouth from brain stem lesions of nuclear centers, the lesion would necessarily be bilateral. Such bilateral lesions of the brain stem involving all the preganglionic salivary centers would be difficult to place experimentally, though perhaps not impossible, and would not be likely to occur clinically. If they did occur there would be such outstanding major losses that their localization would be easily recognized. However, lesions of specific descending systems, such as section of the bundle from the caudal hypothalamus, might upset central equilibrium and be indicated for a time at least by changes in salivary flow.

- 3) Irritative bilateral lesions of the posterior end of the hypothalamus should be evidenced by a dry mouth and throat with de-



creased salivary flow and an inadequate blood supply to the glands. However, irritative lesions of the most rostral end of the hypothalamus and the preoptic area produce definite increase in salivary flow. Destructive bilateral lesions in this same rostral region would markedly decrease reflex salivary flow, since they cut off a very considerable portion of the olfactory impulses to the hypothalamus, without, it is to be noted, interfering with conscious recognition of various odors.

4) It is generally recognized that certain types of lenticular involvement produce sialorrhea.

5) Destructive lesions of olfactory centers or their discharge paths tend to limit the salivary flow to nonolfactory stimuli. Irritative lesions should increase the saliva.

6) Either dry mouth or increased production of saliva may arise as a part of the picture of cortical discharge, the extent and kind of involvement depending upon the site and the type of the lesions, if a demonstrable lesion is present or can be identified in postmortem material.

7) Finally, it should be emphasized that space has permitted the review of only a small part of the literature which might offer explanation for some of the variations of salivary flow. Even so, there are still many intriguing problems along this line for the anatomist and the physiologist.

#### CONCLUSIONS

1. Dysfunction of the salivary glands may be one of the important manifestations of a nervous depression. The diagnosis offers no great difficulty to the otolaryngologist although a satisfactory response to his therapeutic methods is sometimes unobtainable. The otolaryngologist must exercise great caution in not doing or saying something that will crystallize the patient's symptoms and thus render him extremely refractory to subsequent neuropsychiatric care. When one poses an explanation for the individual's ills and predicts successful results from treatment which he proposes to institute, there is always the risk of a therapeutic failure and indissoluble crystallization of the patient's symptoms.

2. There are instances when a dysfunction of the salivary glands is the result of end-organ lesions of the peripheral secretory nerves. This fact seems to have been substantiated by a production of normal salivary flow when pilocarpin is administered. The effect of the drug is augmented by the simultaneous ingestion of the acid-forming salt ammonium chloride. The institution of this treatment for a period

of three to six weeks has been followed in some patients by a return to normal salivation. The exact mechanism by which this result is brought about is not clearly understood; either cellular regeneration occurs spontaneously or medicamentous stimulation of the salivary glands may favor an adjustment to normal function.

3. Organic lesions of the central nervous system may produce a salivary gland dysfunction but they are associated conspicuously with paralysis of other cranial nerves. The scant attention given to the anatomy and pathological physiology of the central pathways of the secretory nerves in the past and our academic interest in this subject are justification, perhaps, for this endeavor to correlate our present knowledge of the anatomy with the function of these pathways.

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## XXIII

### CHRONIC SUPPURATIVE OTITIS MEDIA

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In recent years, our concept of chronic suppurative otitis media has changed. We used to believe that the element of time was an important etiological factor in this disease. There now seems to be a basis for the idea that in most cases of chronic middle ear sup-puration the factor of time is unimportant. Kopetsky<sup>1</sup> expressed this belief when he said: "... chronicities are no more considered in point of 'time'. We have no right to diagnose a lesion by a stop watch or calendar. We must diagnose a lesion by a pathological finding."

This reference to the pathological finding is emphasized when we consider the etiology and pathogenesis of chronic suppurative otitis media. In my personal experience I have observed the develop-ment of chronic middle ear suppuration:

1. *As the sequela of a severe infection causing necrotic change in some portion of the tympanum.* This is not uncommon in severe middle ear infections such as occur in scarlet fever, measles, and diphtheria. The necrotic change may be marked enough so that the ear is destined to chronicity from the occurrence of this necrotic change. This change may involve the mucosa, the ossicles, and the bony walls in addition to the invariable destruction in the drum mem-brane. Granulations and polypi are common. A marginal perfor-ation involving the annular rim of bone allows a ready pathway for an ingrowth of squamous epithelium. This epithelial ingrowth is an attempt on the part of nature to heal the infection; it may invade the space rapidly, proliferate, desquamate, and form a cholesteatoma.

2. *In an acute otitis media in an ear in which the mucosa has remained hyperplastic.* When there has been an interference with the normal development of the tympanic mucosa so that it has re-mained hyperplastic through the effect of an otitis media neonatorum or a catarrhal otitis media in early infancy, this mucosa is considered

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to be poorly resistant to infection. An acute otitis media superimposed on this hyperplastic mucosa is thought to be destined to chronicity. There is, of course, no mastoid pneumatization or very limited pneumatization in this situation inasmuch as the pneumatizing process has never gotten started or has been checked early in its development. Granulations and polypi are common to this type of pathology. Unless there is a marginal perforation the formation of cholesteatoma is not common.

3. *As a result of the formation of a cholesteatoma from an ingrowth of epithelium from Shrapnell's membrane without pre-existing perforation or otitis media.* This ingrowth of epithelium results from a negative pressure in the attic. Two factors may produce this negative pressure. It may result from the closing off of the attic by persistent hyperplastic subepithelial connective tissue in the epitympanic recess, or it may result from a prolonged occlusion of the eustachian tube due to nasopharyngeal pathology. When Shrapnell's membrane is drawn in, a blind pouch forms by the invagination. The neck of this pouch is too constricted to allow escape of the desquamating squamous epithelium. Thus a cholesteatoma forms. Its presence becomes known when it becomes large enough to extend out of the attic, or when saprophytic infection of the epithelial debris causes discharge through the small perforation.

4. *As a complication of ordinary acute otitis media in an ear with normal pneumatization.* Shambaugh, Jr.<sup>2</sup> has said:

"The ordinary acute otitis media never becomes chronic; the patient either dies of a complication or recovers with an intact drum membrane or normal hearing. In acute necrotic otitis media, seen usually in scarlet fever or measles, there is actual necrosis and loss of tissue so that the ear never returns to normal."

To say that an ordinary acute otitis media *never* becomes chronic would make of acute inflammatory phenomena of the normal ear an exception to the changes which may develop in an inflammatory process in any other body tissue. I am satisfied that there are occasional instances of an acute otitis media which does not produce initial necrosis, occurring in a normally pneumatized mastoid, which because of the patient's inability to limit the infection acquires the characteristics of chronicity. It may eventually heal, but with some impairment of aural function and with a sclerotic change in the mastoid picture. These cases are uncommon.

A definition of chronic suppurative otitis is difficult to construct because of the varied pathological possibilities. On the basis of the modern concept of this disease, I am going to suggest this definition:

*Chronic suppurative otitis media is a continued suppuration from the middle ear following an acute necrotic otitis media or a primary suppuration in a middle ear with hyperplastic mucosa; uncommonly it occurs following an invagination of epithelium from Shrapnell's membrane to form a cholesteatoma without pre-existing perforation, or an ordinary otitis media in a previously normal middle ear.*

Any discussion of chronic suppurative otitis media is concerned with the mention of cholesteatoma.

In otology, cholesteatoma refers to an accumulation of horny and desquamated epidermis and cholesterol crystals. The cholesterol results from the decomposition of organic matter out of contact with oxygen.

In reality there are but two types of cholesteatoma, the true and pseudocholesteatoma. It is the pseudo type which we encounter in chronic middle ear suppuration.

Wittmaack's<sup>3</sup> classification contains three types of cholesteatoma. "True" cholesteatoma is a rare tumor usually found accidentally in cranial bones and is considered to be a development from a congenitally misplaced epidermal rest ("Anlage"). The "secondary" type is the one developing from an ingrowth of squamous epithelium through a marginal perforation in the ear drum. The "genuine" type is the one developing from an epithelial invagination in Shrapnell's membrane, a result of the production of a negative pressure in the attic from absorption of air from this space.

The use of terms of similar meaning such as "true" and "genuine" is somewhat confusing. I prefer the use of "primary" and "secondary" to designate the two types of pseudocholesteatoma. The "primary" pseudocholesteatoma is the "genuine" type of Wittmaack.

The "secondary" pseudocholesteatoma is the type commonly encountered in chronic suppurative otitis media. The pathogenesis of this has been described by Lederer<sup>4</sup>:

"When the squamous epithelium of the external canal begins to grow into the perforation, whether in Shrapnell's area or the margin of the tensor portion of the drum, there is an increased activity in the proliferation of the squamous epithelium with a concomitant destruction of the mucosal epithelium. The subepithelial connective tissue with its loose, delicate and richly vascular structure affords an excellent matrix for the squamous epithelium to grow.

"In the absence of erosions the epidermis penetrates into the subepithelial tissue. This is an important occurrence connected with a pathologic condition of the submucosa characterized by inflammatory infiltration of the submucous connective



tissue or by the presence of granulation tissue. The presence of free pus favors the penetration of epidermis, which ceases when granulation tissue starts to regress and is replaced by connective tissue.

"This is followed by resorption of the penetrating epidermis and the splitting of the epidermal cones into clumps. Cells located in the center of the cones become disintegrated thus forming a greasy pulp-like mass rich in cholesterol crystals and fat globules of variable quantity. So here is a mass of the flattened epithelial cells almost devoid of nuclei, arranged in concentric and polygonal lamellae, the outermost being more healthy epithelium. The entire mass is surrounded by a matrix composed of an outer layer attached to the bone and an inner layer identical with the epidermis. The outer layer contains connective tissue poor in nuclei but rich in blood supply. The constant exfoliation which takes place fills the cavity with debris. The mass produces bone destruction by pressure necrosis, the direction of the growth determining the complication.

"Owing to inadequate drainage and moisture the desquamated epithelium finds room for its increased growth only by a concentric spread into the underlying tissue and at the expense of the subepithelial tissue. Further regeneration is only possible in the perivascular connective tissue in the compact bony structure which borders the antrum space; and this process causes bone to be destroyed and absorbed while the cholesteatoma increases in size at the expense of the underlying bone. It had been previously assumed that the cholesteatomatous mass grows into the haversian canals and causes bone destruction. Because of the limited space in the middle ear and inadequate escape of exfoliated epithelium and debris, the tumor assumes a concentric layer arrangement."

#### CLASSIFICATION

I have found it helpful to use a classification of chronic suppurative otitis media suggested by Lillie.<sup>5</sup> It is an empirical, clinical one and is based on the location of the most important pathological change.

In this classification there are four types:

Type I is characterized by a thin mucoid discharge with little or no odor. The discharge comes from a perforation which is in the anterior quadrant of the drum membrane, and the discharge is chiefly from the eustachian tube. Evidence of destructive disease in the middle ear is lacking. This discharge is increased and more purulent during head colds. Contributing factors in the continuation of the discharge are pathologic conditions of the nose and the nasopharynx.

Type II is characterized by pathologic changes confined to the middle ear. The perforation is central, usually large, and the middle ear is filled with mucopurulent or purulent secretion. The odor is fetid but saprophytic changes may suggest caries or cholesteatoma. Granulation tissue or polyps may be present over the promontory. No definite caries is evident although the ossicles may have been de-

stroyed. There may be evidence that the tube is open and discharging. There is no evidence of disease in the attic.

Type III has its most striking pathologic change in the attic although the conditions described in Types I and II may be associated. The odor of the discharge is foul. It may be scanty. The perforation is in Shrapnell's membrane or along the posterior margin of the tympanic membrane. Cholesteatoma is usually present.

Type IV contains all cases in which there are signs of extension of the disease to the labyrinth, meninges, brain or facial nerve. Cholesteatoma is invariably present. Surgical intervention is positively indicated.

#### SOME DIAGNOSTIC CONSIDERATIONS

*Discharge.* The character of the discharge in chronic suppuration of the middle ear may indicate at first examination the nature of the pathologic process. For example, the very foul smelling discharge of a dirty greyish-yellow color suggests cholesteatoma and its degenerating epithelial and osseous association. One may see small white, shiny, greasy flakes in the discharge. These definitely indicate cholesteatoma.

Bacteriologic examination of the discharge from chronic middle ear suppuration offers little of practical value. Secondary invaders such as the staphylococci, the bacilli proteus and pyocyaneus are invariably found in aural discharge which has acquired the characteristics of chronicity.

In cases of primary pseudocholesteatoma (the "genuine" cholesteatoma of Wittmaack) the discharge from the small perforation in Shrapnell's membrane may be very scanty, almost dry, and consist chiefly of flakes of cholesteatoma.

Aural discharge in cases of chronic middle ear suppuration which is not characterized by any of the aspects just mentioned has little diagnostic importance. It should be emphasized, however, that a thin fetid discharge, occasionally or frequently blood-stained, should suggest the possibility of malignancy.

*Objective Signs.* Objective signs in the middle ear exclusive of the discharge are of considerable diagnostic value. Marginal and attic perforations invariably are associated with cholesteatoma in cases of long-standing suppuration. Granulation tissue is indicative of an attempt at repair. A firm bed of granulations in the middle ear as seen

through a large central perforation may indicate a disease confined to the mucosa. When the granulations are large and loose, bare bone can usually be palpated with a probe.

The pressure of a polyp is not in itself an indication of the extent of the pathologic process. The polyp may be simply a part of a mucous membrane change or it may be attached to a site of bone necrosis. Usually removal of the polyp is necessary to study the condition of the middle ear. Removal should be done by use of snare or punch and not by pulling the growth free from its attachment, inasmuch as this latter method carries the risk of opening up pathways of infection.

*Hearing.* Hearing loss in chronic middle ear suppuration varies in degree according to the site and type of the pathology. In the primary pseudocholesteatoma the hearing may be practically normal as long as the disease is confined to the attic.

The average case of chronic middle ear suppuration has a definite loss of useful hearing which is dependent upon the degree of involvement of the medial wall of the tympanic cavity. Any interference with the mobility of the stapes in the oval window may be a greater factor in hearing loss than the perforation in the drum or necrosis of the ossicular chain.

Very marked hearing loss indicates that there has been a deeper involvement than that of the conducting mechanism alone. Absolute deafness associated with chronic suppuration suggests that labyrinthitis has been the cause for this loss. A toxic neuritis not related to a labyrinthitis would be the only other cause to consider.

*Fistula.* The fistula test should be performed in every case of chronic middle ear suppuration of Types III and IV. It may be performed by compressing air in the external canal. This can easily be accomplished by use of a Politzer bag fitted with a tip which fits snugly into the orifice of the external canal.

The onset of vertigo and nystagmus by compression and rarefaction of air in the external canal indicates that there is a fistula through the bony labyrinth with the membranous labyrinth intact. When a fistula is present, it is usually in the external semicircular canal.

When the fistula test is negative, it usually means that the labyrinth is intact although it can mean that there has been a total destruction of labyrinthine function. This latter possibility should

be considered when there is an absolute hearing loss; it can be substantiated by the turning tests in a Bárány chair.

A positive fistula test is indication for surgical intervention in the form of a tympanomastoidectomy.

*Pain.* This is an uncommon symptom in the ordinary case of chronic middle ear suppuration. Its presence is of serious import. It may mean that:

1. Tension has developed due to a stoppage of secretion (pus or cholesteatoma), or
2. The dura or sinus wall has been exposed by the disease and a localized pachymeningitis is present, or a perisinus abscess, or
3. An actual brain abscess is present.

*Vertigo.* Vertigo occurring in the presence of a chronic middle ear suppuration is a serious symptom. Transient attacks with positive fistula test may mean an erosion of the bony labyrinth, usually of the horizontal semicircular canal. Persistent vertigo with nystagmus denotes an actual labyrinthitis in which the membranous labyrinth has been invaded by the inflammatory process.

*Facial Paralysis.* Facial paralysis occurring during the course of a chronic suppurative otitis media is an indication for surgical intervention. Usually it means that an expanding cholesteatomatous mass has eroded the wall of the fallopian canal. The most common site for such an erosion is close to the mastoid antrum or within the tympanic cavity. Surgery for the relief of this complication requires a complete tympanomastoidectomy. Occasionally, an actual decompression of the facial canal might be indicated.

X-ray studies of the temporal bone are necessary in chronic middle ear suppuration before an evaluation of the clinical problem is made. For this, we routinely use the Law, Stenvers, and Towne positions. The latter will reveal any definite enlargement of the tympanic antrum due to an enlarging cholesteatoma.

#### THERAPY

Conservative therapy is indicated in Types I and II of chronic middle ear suppuration. This therapy includes one or more of the following procedures:

1. The local use of certain antiseptic solutions or powders.

2. Minor surgical procedures designed principally to remove diseased tissue, proliferative change, and to improve the drainage.

3. Removal of any upper respiratory tract pathology which might contribute to inflammation of the middle ear.

The well-known alcoholic solution of boric acid owes its usefulness to the alcohol rather than the boric acid content. In addition to its antiseptic properties, the alcohol inhibits to some extent the development of granulations. In an instance of a secreting membrane, such as lines the middle ear space, it should be remembered that alcohol may stimulate this membrane to continue to secrete as long as this medication is in use.

Several powders have been popular in the treatment of chronic middle ear suppuration. The usefulness of any powder depends upon whether the chronic suppurative process is limited and whether the medication will reach the diseased area. Powdered boric acid, boric acid and potassium iodide combination, Sulzberger's iodine powder in two strengths, and more recently powdered sulfonamides have all seemed to have merit. It is my belief that the diagnosis as to the type of disease and the care with which the medication is used are essential in an evaluation of the end result.

Zinc ionization once had a transient popularity. It was probable that the careful cleansing preparations prior to the application of the zinc sulfate solution were an important factor in the good result.

It is important to remove any proliferative tissue changes which may impede drainage and the process of repair. With large perforations, compact granulations can often be reduced with topical applications of silver nitrate in strength ranging from 10 to 50 per cent, or the silver nitrate stick. Large granulations should be removed with small biting forceps. Polyps are removed with a small snare threaded over the polyp. The growth should not be pulled from its attachment inasmuch as there may be attachment of the polyp to an ossicle, particularly the stapes, dislodgment of which would open up a pathway for infection. After cutting through the polyp as close to its base as feasible, the base is treated with applications of silver nitrate.

In selected cases, surgical tympanic and attic drainage should be considered, as recommended by Babbitt.<sup>6</sup> This consists of enlargement of the perforation by surgical incision or biting forceps; then a breaking down of attic adhesions, curetting away of granulations which block drainage, and removal of necrotic ossicles.

A procedure which can be considered minor in comparison with the tympanomastoidectomy is that of ossiculectomy with antral and lateral mastoid drainage as advocated by Tobey<sup>7</sup> and Hill.<sup>8</sup>

Chronic rhinitis, sinusitis, nasopharyngeal lymphoid tissue, and chronic tonsillitis all play important roles in stimulating certain types of chronic suppurative otitis media to continued activity. This is particularly true in Types I and II, in which there is evidence that the infection elsewhere in the respiratory tract seems to be responsible for an occasional exacerbation of the inflammation. This relationship is more commonly encountered in the chronic aural infections of children than of adults. The most common offender in the former group is the lymphoid tissue of the nasopharynx either in the form of the whole adenoid mass, a recurrent growth of adenoids, or the lymphoid tissue in Rosenmüller's fossa.

Conservative treatment is indicated in Type I and most of Type II. When the cholesteatoma is limited to the attic in Type III, a majority of the cases may be successfully treated with attic irrigations, although the perforation may have to be enlarged to accomplish this.

The proper choice of a specific major surgical procedure for chronic middle ear suppuration and mastoiditis depends upon the site and type of the pathology. The objective in the radical management of any case of chronic suppurative otitis media and mastoiditis is first to remove the disease, and thus the danger to life, and second, to preserve as much hearing as possible. The preservation of hearing will in a degree be dependent upon the healing of the internal wall in relation to the amount of scar tissue involving the stapes and to a lesser extent the round window.

It has been advocated that the term "tympanomastoidectomy" be used in place of the more common designation "radical mastoidectomy." Almour<sup>9</sup> in his chapter on the "Surgery of the Chronic Otorrheas" in Kopetsky's *Loose Leaf Surgery of the Ear* states:

" . . . a great deal of misunderstanding has resulted on the part of the general profession and the public as to the purpose and import of the operation. The use of the words 'simple' and 'radical', as applied to mastoidal surgery has led to the erroneous impression among physicians, other than otologists, and the laity that the one is a simple procedure whereas the other entails an extensive technic that endangers the life of the patient. In many instances this attitude has been the cause of unduly postponing surgery for a chronic suppuration of the dangerous type with the resultant death of the patient from a fatal complication. It is felt, therefore, that the abandonment of the term radical mastoidectomy will encourage more timely surgery and thus lessen the number of complications from the dangerous chronic otorrheas. Otologists know too well that a tympanomastoidectomy presents in itself no danger to life beyond the ordinary risks common to all surgery."

In my personal experiences I have employed three types of operations for chronic otitis media and mastoiditis. These are:

1. The complete simple mastoidectomy.
2. The modified radical mastoidectomy (tympanomastoidectomy).
3. The complete radical mastoidectomy (tympanomastoidectomy).

The complete simple mastoidectomy has a very limited application in chronic suppurative otitis media. It may be indicated in a chronic middle ear suppuration in pneumatic bone. When the drum perforation is central, the hearing loss may not be marked with absence of any necrosis of the ossicular chain. In this situation granulations are not prominent in the middle ear. A soft edematous polyp is occasionally encountered protruding through the perforation. The pus is fetid and may vary from a viscid mucopurulent type to a greenish-yellow one. The x-ray films show a pneumatic mastoid with some evidence of decalcification, coalescence, and often some sclerosis. This sclerosis is the result of nature's attempt at repair.

I have seen this picture in what has seemed to be a chronic state developing from an ordinary acute otitis media. The proponents of the idea that an ordinary acute otitis media never becomes chronic would probably argue that this represents only a subacute process or that it fits into the picture of an acute necrotic type of infection of perhaps a minor degree.

The complete simple mastoidectomy in this type of case offers a fair chance of a dry ear. Its technique entails a complete exenteration of the mastoid cavity to healthy inner plate in both the middle and posterior fossae. The horizontal canal is exposed as the mastoid antrum is widely opened and the root of the zygoma is dissected out. This brings into view the incus which is thoroughly exposed at its attachment just external to the horizontal semicircular canal. All granulation tissue that is visible is removed. Occasionally perilabyrinthine cell tracts are encountered which need to be dissected out. I do not hesitate to expose dura over the middle fossa or the lateral sinus if there is any evidence that the plate may have been devitalized.

This operation eliminates the continuing inflammatory process in the mastoid, the antrum and the posterior part of the aditus. Some granulation tissue is usually present in the attic and the posterior part of the middle ear.



The perforation in the drum may heal over or remain open but often the middle ear becomes dry. Clinical experience indicates that this ear, even though healed, is somewhat more susceptible to repeated attacks of otitis media than is a normal ear.

Smith<sup>10</sup> has recommended the removal of the incus in some of these cases inasmuch as it facilitates the removal of granulations from the attic and improves the chances of recovery. He states: "It is remarkable how little effect the removal of the incus has on hearing."

A modified tympanomastoidectomy is indicated in certain cases when there is an adequate opportunity to eliminate the disease without disturbing the ossicular chain or the pars tensa. This means that the disease is limited to the attic, antrum and mastoid.

This type of operation is ideally suited to the cure of cases of primary pseudocholesteatoma of the attic (the "genuine" cholesteatoma of Wittmaack) which have not responded to attic irrigation.

I have used the Bondy<sup>11</sup> type of operation with very satisfactory results. Lillie<sup>12</sup> and Shambaugh, Jr.<sup>13</sup> have reported good results with the operation. The latter recommends primary skin grafts to shorten the healing period.

The technique for this procedure will be commented on later.

The complete radical mastoidectomy (tympanomastoidectomy) is indicated in all cases of chronic suppurative otitis media and mastoiditis with extensive secondary cholesteatoma, and in any case in which there are signs of the extension of the disease to the labyrinth, facial nerve, lateral sinus, meninges, or brain.

An operation of this extent is required to eliminate the disease from the middle ear, the antrum and the mastoid space. When this has been accomplished, these areas have been converted into one smooth-walled cavity. A lining of squamous epithelium is anticipated.

Many otologists now use the Lempert<sup>14</sup> endaural approach for tympanomastoidectomy. We began using this approach in 1940 at the University of Minnesota. To date we have observed its usefulness in a total of 82 cases of tympanomastoidectomy; 14 of these were of the modified type. During the period these 82 patients were operated on by the endaural approach, an additional 16 were operated on by the postaural route. In my opinion the advantages of the endaural approach are:

1. There is less soft tissue disturbance.
2. The operative maneuvers are more directly over the middle ear and antrum where usually the most important work is centered. It seems to be a perfect approach for the modified tympanomastoidectomy.
3. The construction of the plastic flap is simplified.
4. Postoperative care and discomfort is lessened.

Woodruff and Henner<sup>15</sup> and Babbitt<sup>16</sup> have found this approach advantageous. The former have obtained a greater percentage of dry ears with this approach than by any other method.

#### TECHNIQUE OF TYMPANOMASTOIDECTOMY

The operative field is prepared in the usual manner except that there is no need of shaving the hair in the postauricular area.

Several cubic centimeters of a 1:10,000 solution of epinephrine hydrochloride are injected into the skin and periosteum of the membranous portion of the posterior wall of the external auditory canal internal to the anterior border of the concha. Then injection is also made into the skin, fibrous tissue and periosteum of the antauricular, suprameatal membranous triangle.

It is difficult to convey a word picture which will make you accurately visualize the incisions in the endaural approach. One should refer to Lempert's<sup>14</sup> illustrated descriptions and then practice it on the cadaver.

I have found the incisions Lempert uses for the creation of the window for simple mastoidectomy adequate for the tympanomastoidectomy and possessed of a certain advantage. This advantage consists of a larger epithelial flap to lay back over the posterior wall of the completed operative cavity. After I have completed the membranous window (as for a simple mastoidectomy), the posterior half of the membranous canal is separated and retracted from its attachment at the annulus. This procedure is followed for the modified tympanomastoidectomy as well as in the complete operation. Some operators incise the skin of the posterior and superior walls of the bony canal close to the annulus before retracting the membranous canal. This is to prevent injury to the tympanic membrane. However, the attachment of the pars tensa to the annulus is so strong that the membranous canal can be separated without injury to the drum membrane.

At the conclusion of the operative work on the mastoid and middle ear, the membranous canal is slit from without inward through the middle of its posterior wall. The flaps are thinned of subcutaneous connective tissue. One part is tucked back over the facial ridge and the other upward. A large soft rubber tube is placed to hold these flaps in position.

The motor driven burr is an advantage for the gross work on the bone. It causes a minimum amount of trauma and bone can be removed rapidly with a light touch and a considerable factor of safety. The Lempert curettes are preferable for the finer bone work.

There are five essential steps in the bone work in the performance of a tympanomastoidectomy:

1. Opening the mastoid antrum. A burr is directed through the spine of Henle and continued inward paralleling the posterior bony canal wall. As one approaches the antral space, the postero-superior margin of the annulus provides an important guide. As soon as the antrum has been reached, a probe can be used to determine its limits and then the work of completely exposing this space may proceed. Curettes and the burr are used alternately for this.

2. Performance of a simple mastoidectomy. At the completion of this second step, the most important landmark for the remainder of the work is now visible. The landmark is the horizontal semi-circular canal.

3. In a complete tympanomastoidectomy, the connecting of the cavity of the antrum and mastoid with the middle ear space. In the technique of exposing the antrum with the motor driven burr, a considerable portion of the posterior canal wall has already been removed, usually at least the outer half. There remains, in order to connect the cavities of the antrum and the middle ear, a complete removal of this posterior canal wall up to where it joins the tegmen above. Then attention is directed to the portion of the external canal wall between the level of the horizontal canal and the tegmen above. The portion of this forming the outer wall of the aditus and attic is commonly referred to as the "bridge." As the external wall between the level of the horizontal canal wall and the tegmen is reduced, the incus, if it has not been destroyed by disease, becomes exposed.

Removal of the "bridge" can be very satisfactorily accomplished with a small curette (No. 0 or smaller). The curette is placed so that its back points internally and the cutting edge is just inside this bridge of bone. The bridge is slowly thinned down with the curette whereupon it breaks through and is carefully removed until the

tympanic ring is reached and broken through. The attachment of this posterior canal wall to the tegmen should be smooth so that the tegmen of the tympanic space, the antrum and the mastoid form one smooth surface, the roof of the operative cavity. A spur of bone is prominent on the facial ridge just at the lower level of the eminence of the horizontal canal. This is often referred to as the "facial spur" and should be removed so that there is no overhang between it and the smooth bulge of the horizontal canal or the course of the fallopian canal as it turns to cross within the medial wall of the tympanic cavity.

When a cholesteatoma is encountered, an effort should be made to preserve the matrix inasmuch as it provides an epithelial lining and thus hastens the postoperative healing.

4. Work on the tympanic cavity. The incus, if any remains, is removed. Any remains of the malleus and the tympanic membrane are removed. The middle ear space is cleaned of granulations. A small curette is used to remove the remains of the tensor tympani muscle and its bony canal and the processus cochleariformis. The tympanic orifice of the eustachian tube is then identified. In most cases a eustachian curette can be inserted into the orifice of the tube to curette the lumen gently in the hope of stimulating scar tissue which will close the tube. When the tympanic cavity has been filled with a cholesteatoma, the tube has often been closed by the matrix. This usually insures freedom from tubal discharge postoperatively.

5. The final phase of the bone work. The facial ridge is lowered to the level of the floor of the external auditory canal. It is also desirable to lower the floor of the external auditory canal at its junction with the hypotympanum so that the level of the floor of the canal approximates the hypotympanum. The motor driven burr works efficiently and safely for these procedures.

The performance of a modified tympanomastoidectomy, which has for its purpose the preservation of the ossicular chain and membrana tympani is varied technically from the complete tympanomastoidectomy only in that these structures are preserved but the entire attic is exposed and all diseased tissues within it removed.

#### SKIN GRAFTING

Skin grafting shortens the period of epithelialization sometimes by weeks. Some otologists graft at the completion of the operation; others graft ten days to two weeks postoperatively. This latter would

seem the more logical inasmuch as it provides a bed of granulations on which to graft instead of a wall of smooth bone. However, a postoperative graft has a disadvantage if the operative cavity is kept open or re-opened for it.

Grafting over exposed dura or lateral sinus is to be avoided inasmuch as a portion of the graft always decomposes and invariably there is a certain amount of retained secretion and infection at the site.

Two methods of placing and maintaining the graft in the desired position have proven very satisfactory in our experience. One is the use of the Mosher basket.<sup>17</sup> The other is the method of Daggett and Bateman<sup>18</sup> which is as follows: Skin on the thigh is painted with one per cent methylene blue in alcohol and allowed to dry. Then a thin layer of collodion is applied. These applications allow easy identification of the graft and when cut it will not roll up. Small pieces of the graft are applied through the meatus. Then a melted wax of the following formula is poured into the cavity:

Benzyl-naphthol .....	0.25
Oil of eucalyptus .....	2.0
Olive oil .....	5.0
Paraffin q. s. ad .....	100.0

This wax plug is removed in approximately two weeks.

#### POSTOPERATIVE CARE

Every otologist who has had experience with radical mastoid surgery has encountered cases where an expenditure of a great deal of effort to secure dermatization has not met with quick success. And in contrast, there have been cases in which epithelialization has progressed and been completed without the necessity of any particular aftercare effort.

Some writers indicate that a daily treatment for a period of three or four weeks or more is essential to insure a dry ear quickly.

It is our practice with an endaural tympanomastoidectomy to discharge the patient from the hospital approximately one week after the operation. He is usually seen then two or three times in the following one week and then at four- or five-day intervals until the progress of the epithelialization insures a rapid accomplishment of the healed state.

The most important aspects of treatment are to keep down exuberant granulations which prevent the advance of the epithelium and the removal of excess secretions. The former may require silver nitrate cauterization or actual removal of granulations with a punch forceps. The removal of excess secretion may be accomplished by gentle wiping of the canal or by suction. One should bear in mind that excessive wiping may injure the advancing epithelial edge. Instillation of absolute alcohol tends to keep down the formation of granulations.

Crystalline urea applied topically is used to reduce granulations in some cases.

I have observed more than one case in which granulations have been "fought" unsuccessfully only to have the patient return after an absence of a month or two with a dry ear and an epithelialized cavity.

#### CAUSES OF FAILURE

The patient usually measures success in radical mastoidectomy in terms of a dry ear. The primary objective of the operation, removal of a dangerous infection, may have been accomplished but a continued or intermittent drainage is a disappointment to the patient. Of course, this may mean inadequate removal of diseased bone. In that case, the discharge will have the character of suppuration from bone.

There is only one answer to this situation. This is more apt to occur in a case of secondary cholesteatoma following an acute necrotic otitis on an extensively pneumatized temporal bone.

Otherwise, continued discharge is the result of incomplete epithelialization in which a granulating surface discharges or secretion comes from the eustachian tube. Tubal discharge is usually mucoid. It may come from secreting mucosa in the tube or from nasopharyngeal infection.

Though the aim of curettage of the tympanic end of the tube is to cicatrize the lumen so that fibrosis results, it is probably impossible to close some tubes by this measure. Some ears undoubtedly remain dry with a patent tube. The fortunate situation is one in which middle ear disease seals off the tube before surgery is performed.

In any instance of discharge from the tubal opening in an otherwise epithelialized cavity, proper habits of nose blowing, prevention of upper respiratory tract infection in so far as is possible, and at-

tention to local hygiene of the aural cavity are all that are necessary to keep this discharge at a minimum.

## SUMMARY

1. Our understanding of chronic suppurative otitis media has changed. It is rarely the result of a neglected acute otitis media. The occurrence of a necrotic acute otitis media or a primary suppuration in a middle ear with hyperplastic mucosa often creates a middle ear infection which is destined to chronicity from the onset of the infection.

2. A simplified classification (Lillie) of chronic suppurative otitis media offers a useful means of visualizing the pathology and the application of therapy in any particular case.

3. The evaluation of local therapy in the form of solutions or powders is convincing only when the type of the pathology is considered in the particular case.

4. An experience with the endaural approach in 82 operations for chronic suppurative otitis media has revealed certain advantages with this approach.

78 SOUTH NINTH STREET.

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XXIV

PLASMA CELL TUMORS OF THE UPPER PART  
OF THE RESPIRATORY TRACT

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Myelomas are usually defined as tumors arising in bone marrow. However, there is considerable question whether classic multiple myeloma is an intrinsic disease of the bone marrow or a disease of the blood-forming structures generally. Solitary plasma cell myelomas or plasmocytomas may be of extra-osseous origin; such neoplasms at times develop in the upper part of the respiratory tract as well as elsewhere in the body. The cause and nature of these tumors and their relationship to multiple myelomas are not definitely known. They have been looked upon by different observers as inflammatory or granulomatous masses, and also as benign and as malignant neoplasms.

This report is based on a study of 11 cases of solitary plasma cell myeloma of the upper part of the respiratory tract which were observed at the Mayo Clinic in a period of 14 years, namely, from January 1, 1930, to December 31, 1943, inclusive. In this consideration an attempt will be made to clarify some of the confusion associated with these tumors.

As has been noted by New and Harper<sup>1</sup> multiple myeloma generally occurs in the fourth or fifth decade and usually causes death in a few months to four years. The neoplasm is considered by most authors to be a hypertrophic tumor of the hematopoietic system, usually of the bone marrow. However, the hematologic picture usually is not affected until the later stages of the disease when more or less severe secondary anemia may develop. Bence-Jones proteinuria is present in approximately 80 per cent of cases. This is in contrast with the situation existing in cases of plasmocytoma, in which Bence-Jones protein is rarely if ever present in the urine prior to the development of multiple osseous lesions.

Solitary plasma cell myelomas of the upper part of the respiratory tract are rare. Claiborn and Ferris<sup>2</sup> found only 12 cases in which such tumors involved the nose and nasopharynx recorded in the literature prior to 1931. They presented an excellent review of these cases and added two cases which they had observed. Cappell<sup>3</sup> in a group of 122 cases of tumor of the nose and throat found only two cases of plasmocytoma. New and Childrey<sup>4</sup> observed two instances of this type of tumor in 230 cases of malignant neoplasm of the palate, oropharynx and tonsil. Mattick and Thibaudeau<sup>5</sup> found 19 cases of plasma cell tumors of the upper air passages reported in the literature prior to 1935 and added one which they had observed. Jackson, Parker and Bethea<sup>6</sup> presented a study of 17 cases of multiple myeloma, in five of which solitary plasma cell myelomas preceded the generalized involvement.

Plasma cell myelomas occur more often in males than in females, and they usually occur after the age of 40 years. In the 11 cases which form the basis of this paper, seven of the patients were males and four were females. Their ages ranged from 37 to 71 years. All but one of the patients were more than 40 years of age.

Plasmocytomas may arise in various situations. Extramedullary plasmocytomas most frequently are seen about the pharynx, palate, nose and accessory nasal sinuses. They may originate in any portion of the upper part of the respiratory tract. The literature contains reports of cases in which the tumor was situated behind the ear, in the mastoid cells, on the alveolar process, on the scalp, on the conjunctiva, on the arms and on the tongue. In the present series of cases, the site of the tumor was as follows: in the maxillary sinus in six cases, the oropharynx in two cases, the nasopharynx in two cases and in the larynx in one case. In both cases in which the oropharynx was involved, the tumor had originated in the right tonsil. In one of the cases in which the tumor involved the nasopharynx, the tumor had originated in the sella turcica or in the sphenoid sinus and had involved the nasopharynx secondarily. In some cases in which the lymph nodes were involved, a question arose as to whether the tumor had originated in these structures or had extended into them secondarily. Although the exact cause of this type of tumor is not definitely known, it is generally thought that it develops from the small and large lymphocytes.

In cases of plasmocytoma of the upper part of the respiratory tract, the history varies greatly depending on the situation of the lesion and its activity. In most instances, symptoms have been present for less

than six months but they may have been noted for a year or more. The most common symptoms that we have encountered are swelling of the cheek, nasal obstruction and frontal headache. In most of the cases in which the condition is primary in the mouth or pharynx, the patients are aware of the presence of a tumor and some of them experience difficulty in swallowing. In one case, a mass had been noted in the neck externally as well as inside the pharynx. In cases in which the tumor is primary in the accessory nasal sinuses, most often in the maxillary sinus, the symptoms are localized pain, headache, swelling and soreness of the cheek and upper jaw, nasal obstruction, diplopia and exophthalmos. In some of these cases teeth have been extracted because of the swelling of the alveolus and a sinus has persisted at this site.

One patient with a primary tumor which was situated in the region of the sella turcica and the sphenoid sinus and extended into the nasopharynx, complained of nasal obstruction, a sense of fullness in the left side of the face, progressive deafness, occipital headache and unilateral impairment of vision. Another patient with a tumor of this type in the nasopharynx had no symptoms whatsoever referable to it. He came to the Clinic because of vague pain in the thorax. No organic cause for the pain was demonstrable and a plasmocytoma of the nasopharynx was found on routine examination of the nose and throat.

The general appearance of patients with tumors of this type has varied with the stage of the disease. Some of them were in good general health and showed no evidence of systemic effects of the neoplasm. Others had the cachexia, anemia, weakness and disability usually associated with an advanced malignant tumor.

Physical examination in these cases generally has revealed a tumor that appeared highly malignant (Fig. 1), which was in keeping with the usual short duration of symptoms. In a few instances the mass has had a polypoid appearance. Ulceration usually has not been present except after previous treatment. In all of the cases in which there was primary involvement of the maxillary sinus, the findings were indicative of a malignant neoplasm. Bulging of the palate, alveolus, cheek and lateral wall of the nose, complete density of the maxillary sinus on transillumination, and elevation and, at times, proptosis of the eye were present. In two instances the tumor was on the point of perforating the skin of the cheek. Ulceration of the alveolus or palate was present in the cases in which dental extraction or other operative procedures had been carried out.

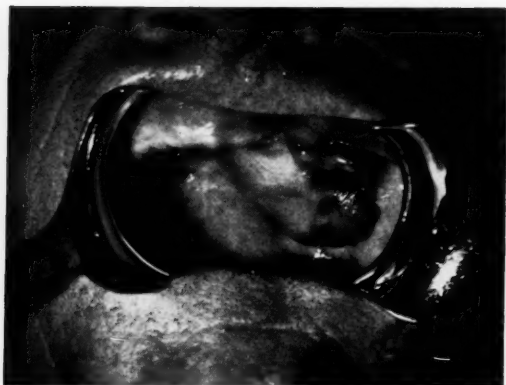


Fig. 1.—Extensive plasma cell myeloma of the upper jaw, maxillary sinus, nasal fossae, ethmoid cells and frontal sinus of a man, 64 years of age. A tumor of the mouth had been present for four months.

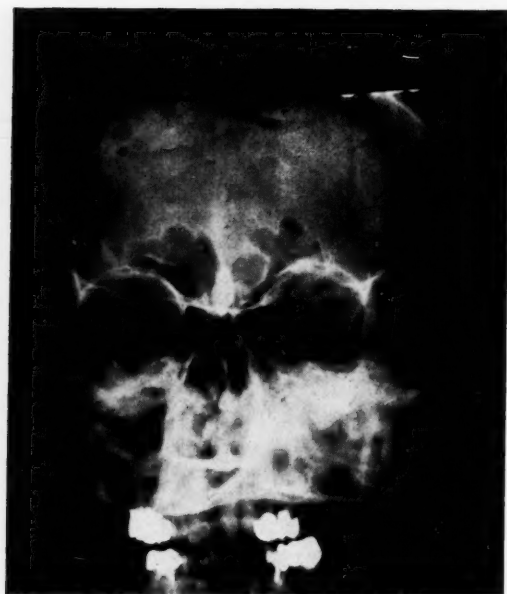


Fig. 2.—Numerous metastatic tumors of bone secondary to plasma cell myeloma of the right upper jaw, maxillary sinus and nasal fossa.

In one case in which the tumor had originated either in the sella turcica or in the sphenoid sinus, a sessile mass protruded from the vault of the nasopharynx and almost completely blocked both choanae. In another case a symptomless pedunculated tumor, 2.5 cm. in diameter, was attached to the right side of the posterior wall of the nasopharynx.

Clinical evidence of involvement of the regional lymph nodes was noted in only one of the cases in this series. In this case, the tumor which originated in the right tonsil, had an ulcerated polypoid appearance and measured 3 by 2.5 by 2.5 cm. while the metastatic involvement of the lymph nodes in the right cervical region was 4 cm. in diameter.

Roentgenographic studies of the bony structures of the involved region and of the thorax were made in all of these cases. In cases in which the neoplasm involved the accessory sinuses, roentgenographic examination frequently showed much more extensive involvement than was suspected from the clinical findings. In several instances a tumor that appeared clinically to involve only the maxillary sinus and nasal fossa was found by roentgenographic examination to be present in the ethmoid cells and frontal sinus as well. In this group, too, malignant destruction of the floor and walls of the maxillary sinus, ethmoid cells, orbit, nose and zygoma at times was evident. In one case in which a nonulcerated tumor protruded from the vault of the nasopharynx, roentgenograms showed extensive destruction of the sella turcica and cloudiness of the sphenoid sinus, which revealed either of these regions as the site of origin of the neoplasm. Roentgenograms of the thorax were normal in all of the patients at the original examination at the Clinic.

Only in one of the 11 cases was metastatic involvement of bone demonstrable roentgenographically at the time of the primary examination at the Clinic (Fig. 2). This was a case of a huge, rapidly recurring tumor of the upper jaw, maxillary sinus, ethmoid cells and nasal fossa. Roentgenographic examination of the maxillary sinus disclosed not only extensive destruction of the upper jaw, maxillary sinus and ethmoid cells but what appeared to be multiple areas of metastatic destruction throughout the skull as well. The patient had no symptoms referable to the secondary tumors. The metastatic involvement might well have furnished a clue to the nature of the lesion had the patient been observed prior to partial removal of the neoplasm of the superior maxilla and cheek. The trauma attendant on this therapy had produced extensive sloughing and inflammatory reaction so that the condition strongly suggested a fulminating type of squam-

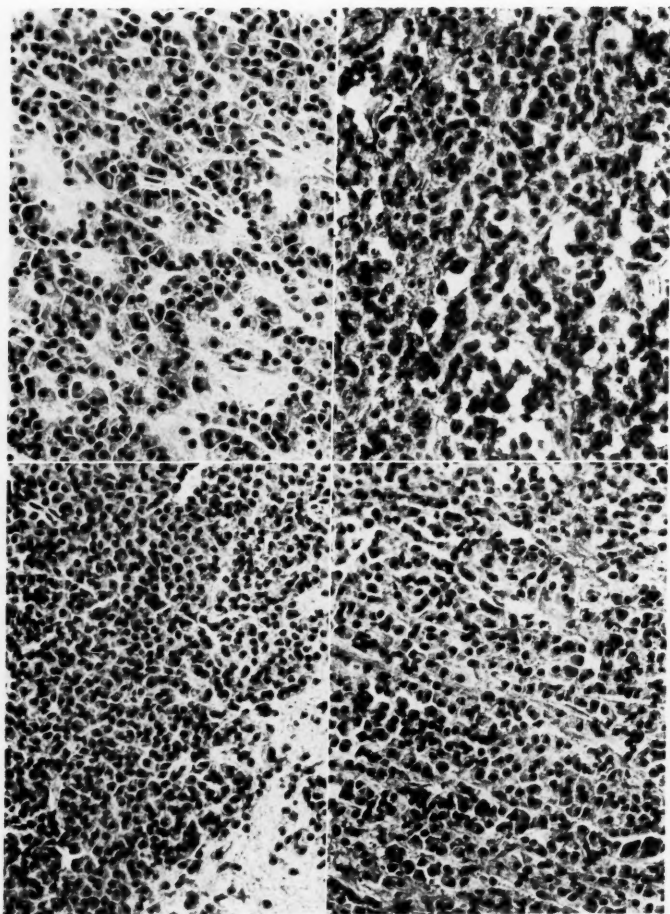


Fig. 3.—Plasma cell myeloma of the pharynx (Case 1) showing both diffuse and single-file arrangement of cells (x203).

Fig. 4.—Plasma cell and so-called lymphocytic myeloma of the larynx (Case 3) showing densely packed cells (x203).

Fig. 5.—Plasma cell myeloma of the nasopharynx (Case 8) showing diffuse arrangement of cells (x203).

Fig. 6.—Plasma cell myeloma of the maxillary sinus (Case 9) showing diffuse and single-file arrangement of cells (x203).



ous cell carcinoma. Although the tumor of the upper jaw and maxillary sinus had been noticed by the patient for only three months, it was assumed that the malignant process was primary in this situation and that the smaller deposits throughout the calvarium were secondary.

#### REPORT OF CASES

CASE 1.\*—A man, aged 60 years, who came to the Clinic on April 30, 1930, had had tinnitus in the right ear for two years and a tumor in the throat and in the cervical region for two or three months. He had been having frontal headache for the past two or three months. Clinical examinations revealed an ulcerated, polypoid mass measuring 3 by 2.5 cm. in the right side of the pharynx, arising in the tonsil. There was also a mass, 4 cm. in diameter, in the right side of the neck. No tumors were demonstrable elsewhere. Bence-Jones proteinuria was absent.

Microscopic examination of tissue taken from the pharynx revealed a plasma cell myeloma (Fig. 3). Interstitial irradiation was carried out for the mass in the neck and the tumor in the pharynx, and roentgen therapy was applied. The mass in the pharynx and that in the neck disappeared slowly and the patient's general health improved. At the time the patient was last observed, on October 15, 1942, he had actinodermatitis of the right side of the neck but there had been no recurrence of the myeloma.

CASE 2.—A man, aged 60 years, came to the Clinic on July 25, 1934, because of a choking sensation and difficulty in swallowing solid food, which had been present for one year. Clinical examination revealed a nonulcerated, polypoid-appearing mass which measured approximately 4 by 3 by 2 cm. and involved the right tonsil. This was thought to be lymphosarcoma. There was no enlargement of the regional lymph nodes. Bence-Jones proteinuria was absent.

Tonsillectomy was performed. Microscopic examination revealed a plasma cell myeloma. Roentgen therapy was employed post-operatively and again three months later. On October 11, 1934, bilateral antral windows were made for suppurative sinusitis.

When the patient returned for a check-up on June 12, 1942, he said that he had had no symptoms referable to the lesion of the throat until six weeks previously, when soreness had developed in the anterior part of the thorax, especially over the sternum and ribs. This

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\*This case has been reported previously by New and Harper.

had been aggravated by coughing or sneezing. He had lost 8 to 10 pounds (3.6 to 4.5 kg.) and complained of increasing weakness. Coughing produced a dark brown sputum. No recurrence of the tumor was present in the pharynx but multiple small hard nodes were palpable in the right cervical region and multiple metastatic tumors (myelomas) of the ribs and clavicles were revealed by roentgenographic examination of the thorax. Bence-Jones proteinuria was present. Roentgen therapy was employed. The patient has not been heard from since he left the Clinic after his return for a check-up.

CASE 3—A man, aged 62 years, who came to the Clinic on May 27, 1935, had had huskiness of the voice and bleeding of the throat 16 years previously. At that time, a "mulberry" mass on the left side of the pharynx had been treated with roentgen rays and radium. He had experienced no further trouble until a year and a half before he came to the Clinic, when hoarseness and the mass in the throat had recurred and a piece of tumor tissue had been coughed up. Radium again had been applied but the hoarseness had continued. Acute pain and soreness of the throat had been present for a month before he came to the Clinic. He had lost 25 pounds (11.3 kg.), presumably owing to dysphagia.

Examination revealed a pedunculated nodular mass, about 2.5 cm. in diameter, which involved the left margin of the epiglottis and aryepiglottic fold. Delayed sloughing, which was due to radium therapy, was present at the base of the tongue. Roentgenograms of the long bones were normal and there was no Bence-Jones proteinuria.

On June 25, 1935, the tumor was removed. The pathologist reported that the tumor was a myeloma (Fig. 4). This tumor was not a typical plasma cell myeloma as it also contained cells that were comparable to the cells of a so-called lymphocytic myeloma or lymphocytoma. Radium was applied subsequently. On November 13, 1942, examination did not reveal any recurrence of the tumor. Actinodermatitic lesions in each submaxillary region were excised. Roentgenographic examination of the long bones did not disclose any abnormality. Bence-Jones proteinuria was absent.

CASE 4.—A woman, aged 54 years, came to the Clinic September 2, 1936, because of a tumor of the right cheek which had been present for three months. A right upper tooth had been extracted a few days after the enlargement first had been noted and a discharging sinus had been present continuously since the extraction. An indurated region inside the cheek had been excised one week before the patient came to the Clinic.

The patient was very obese. Examination revealed a huge, rapidly growing malignant tumor of the right upper jaw, maxillary sinus and nasal fossa. A sloughing ulcer was present on the surface of the tumor inside the mouth. General physical examination did not disclose any other abnormality and roentgenograms of the thorax were normal. Roentgenographic examination of the accessory sinuses revealed extensive destruction of the right maxillary sinus and apparent multiple regions of metastatic destruction throughout the skull. Bence-Jones proteinuria was not checked. Biopsy revealed that the tumor was a plasma cell myeloma. Electrocoagulation and insertion of radium was carried out and roentgen therapy was applied to the face and skull subsequently.

At the time of observation 21 months later (June 9, 1938), no local recurrence of the tumor was present but the patient was having severe pain in the neck, shoulders and arms, and roentgenographic examination revealed extensive metastatic involvement of the skull, ribs, spinal column and pelvis. The patient died on November 30, 1938.

CASE 5.—A woman, aged 37 years, came to the Clinic on February 13, 1937, because of "sinus trouble" in the right maxillary sinus, which had been present for four months. In addition, she stated that she had noted diplopia and decreased vision in the right eye and swelling of the right cheek for one month. A Denker operation had revealed that a tumor filled the maxillary sinus. The sinus had been curetted and microscopic examination had disclosed that the tumor was malignant.

Clinical examination revealed an extensive malignant tumor of the right maxillary sinus. The tumor had caused bulging of the floor of the orbit and of the cheek. Roentgenographic examination revealed diffuse opacity of the frontal sinus, ethmoid cells and maxillary sinus on the right side, but no evidence of destruction of bone. Roentgenograms of the thorax were normal. No Bence-Jones protein was found in the urine. Examination of the tumor which had been removed disclosed a myeloma.

An exploratory operation was performed through the previous operative incision above the alveolus and radium needles were inserted into the tumor. Subsequently, radium packs were applied externally. The patient died of meningitis five months later.

CASE 6.—A woman, aged 47 years, came to the Clinic on January 9, 1937. Obstruction of the left side of the nose and progressive impairment of hearing in the left ear had been present for one year.

A sensation of fullness had been present in the left side of the face for six months, and impaired vision in the right eye and occipital headache had been present for three or four months. Three months before the patient came to the Clinic, biopsy had revealed a benign nasal tumor, but nine days before the patient came to the Clinic another biopsy had disclosed that the tumor was malignant. Roentgen therapy had been employed on numerous occasions.

Examination at the Clinic revealed a tumor in the midline of the nasopharynx. The tumor extended downward from the vault and almost completely blocked both choanae. Roentgenographic examination of the sella turcica revealed extensive destruction and cloudiness of the sphenoid sinus due to a large primary intrasellar tumor which had extended into the sphenoid sinus. Bence-Jones proteinuria was not checked. No roentgenograms of the long bones were made but roentgenograms of the thorax were normal. Examination of a section of the tumor which was sent to us revealed that the tumor was a plasma cell myeloma.

Seven hundred milligram hours of radium was applied directly to the nasopharynx with a T-applicator and the patient was directed to continue roentgen therapy at her home. In a letter written 20 months later (September 11, 1939), the patient stated that she had made almost miraculous progress and was working right along.

**CASE 7.**—A woman, aged 70 years, came to the Clinic on June 21, 1937, because of rapidly increasing swelling of the right cheek which had been present six weeks. She complained of nasal obstruction but had no pain. She had lost ten pounds (4.5 kg.) in six months. She had some difficulty in focusing her right eye. Her family physician had told her that she had a tumor of the right maxillary sinus.

Examination revealed an extensive malignant tumor of the right maxillary sinus and nasal fossa. The tumor had elevated the right eye and had caused bulging of the cheek and palate. The tumor was on the point of perforating the skin just below the inner canthus. Roentgenographic examination revealed destruction of the greater portion of the bony margins of the right maxillary sinus and of a portion of the zygoma. Roentgenograms of the thorax were normal. Bence-Jones proteinuria was not checked.

An exploratory operation was performed and radium was inserted into the tumor, which involved the right maxillary sinus, the ethmoid cells and the nasal fossa. Microscopic examination disclosed that the neoplasm was a myeloma. Radium packs were applied sub-

sequently. The primary response to treatment was highly satisfactory but after a brief period there was progressive failure and death occurred about nine months after the patient came to the Clinic.

CASE 8.—A man, aged 48 years, came to the Clinic on August 30, 1938, because of aching pain which had been present in the right side of the thorax for a year and a half. Routine examination of the nose and throat revealed a pedunculated tumor, 2.5 cm. in diameter, which was attached to the right side of the posterior wall of the nasopharynx. The tumor was visible below the border of the palate and grossly did not appear to be malignant. Bence-Jones proteinuria was absent. Roentgenographic examination did not disclose any abnormality of the cervical vertebrae, right shoulder, thorax or skull.

The tumor was clipped off and 500 mg. hours of radium was applied to the nasopharynx. Roentgen therapy was applied twice. Microscopic examination of tissue removed from the tumor revealed a plasma cell myeloma (Fig. 5). At the time the patient was last seen, on April 7, 1941, there had been no recurrence of the tumor.

CASE 9.—A man, aged 55 years, who came to the Clinic on April 17, 1940, said that he first had noticed a tumor of his left upper jaw five months previously. This had been removed a month and a half before he came to the Clinic and it had been reported as malignant. Roentgen therapy and radium therapy had been advised but the patient had refused the treatment.

Roentgenograms of the sinuses showed increased density of the floor of the left maxillary sinus. Roentgenograms of the thorax were normal. The urine was not checked for Bence-Jones protein.

Exploration of the left maxillary sinus was carried out through the previous operative scar. The sinus appeared normal except for slight elevation of the floor. Biopsy revealed a plasma cell myeloma (Fig. 6). Electrocoagulation was carried out and 1000 mg. hours of radium was applied to the sinus. At the time the patient was last seen at the Clinic, on August 12, 1940, no recurrence of the tumor was evident.

CASE 10.—A man, aged 55 years, came to the Clinic on October 1, 1941, because of a tumor which had caused bulging of the upper part of the left cheek. He had noted soreness of the left upper first molar tooth six months previously. After extraction of the tooth, he had been advised to consult a rhinologist.

His general health was good. Examination revealed an extensive malignant tumor of the left maxillary sinus. The tumor had per-

forated the anterior part of the outer wall and the floor of the orbit and had caused bulging of the naso-antral wall and of the cheek. Roentgenograms revealed a duodenal ulcer. Roentgenograms of the thorax were normal. Bence-Jones proteinuria was absent. The eye was elevated and proptosis was present.

The left maxillary sinus was explored through the cheek externally. The tumor apparently had originated in the upper part of the maxillary sinus. The bony floor of the orbit had been destroyed and the ethmoid cells were filled by the neoplasm, which proved to be a plasma cell myeloma. Electrocoagulation was carried out. Radium packs were applied subsequently. Sternal aspiration revealed an increased number of normal plasma cells but no myeloma cells or other pathologic elements. At the time the patient was last observed, on December 3, 1943, he was in good general health and there had not been any recurrence of the neoplasm.

CASE 11.—A man, aged 64 years, came to the Clinic on July 12, 1943, because of a tumor of the left upper jaw which had been present for four months. This had grown rapidly after having been incised a few weeks previously and was producing nasal obstruction. The patient's general health was good.

Examination revealed an extensive highly malignant tumor of the left upper jaw, maxillary sinus, nasal fossa and nasopharynx. There was no palpable enlargement of the regional lymph nodes. Bence-Jones proteinuria was absent.

Biopsy revealed that the tumor was a plasma cell myeloma. Electrocoagulation and interstitial irradiation were carried out. Radium packs were applied over the face and neck subsequently and this treatment was repeated later. In December 1943, the patient returned because of an extensive recurrence of the neoplasm involving both maxillary sinuses, both nasal fossae, the ethmoid cells on both sides and both frontal sinuses. Further electrocoagulation and insertion of radium were carried out and roentgen therapy was employed post-operatively. In July 1944, the patient returned because of a tumor, approximately 4 cm. in diameter, which was attached to the outer aspect of the fifth rib in the left midaxillary line. Roentgenograms of the thorax were normal and Bence-Jones proteinuria was not demonstrable. The mass receded promptly after the use of roentgen therapy. Examination on November 9, 1944, showed several subcutaneous nodules distributed in the region of the left thoracic wall, the anterior abdominal wall and the left thigh. Roentgenograms revealed what appeared to be a pathologic fracture of the left fifth rib.

Roentgen therapy was again given but it was anticipated that this would afford only temporary palliation. The patient died on April 14, 1945.

*Comment.* One case (Case 2) is of particular interest and especially enlightening since it strongly suggests the probable relationship between a solitary, extramedullary plasmocytoma and multiple myelomas. The patient, a male 60 years of age, entered the Clinic on July 25, 1934, complaining of a choking sensation and difficulty in swallowing of a year's duration. Examination revealed marked enlargement of the right tonsil owing to a polypoid mass measuring 4 by 3 by 2 cm. A clinical diagnosis of probable lymphosarcoma was made. Microscopic examination, after tonsillectomy, revealed that the tumor was a plasma cell myeloma. Roentgen therapy was given postoperatively and this was repeated three months later. The patient had no further difficulty and remained in good general health until almost eight years later. Soreness then developed over the anterior portion of the thorax, particularly over the sternum and the ribs. This was aggravated by coughing and sneezing. Expectoration was painful and produced a dark brown sputum. During the course of about six weeks the patient lost between eight and ten pounds (3.6 to 4.5 kg.) and became progressively weaker. Upon his return to the Clinic on June 12, 1942, no local recurrence of the tumor in the pharynx was demonstrable but multiple, small, hard nodules were present in the right cervical region and roentgenographic examination revealed multiple myelomas of the ribs and clavicles. Bence-Jones proteinuria, which was absent at the time of the patient's original examination, was now present. Further roentgen therapy was given. The patient has not been heard from since then and it is thought that death probably occurred shortly after his last visit to the Clinic.

The lymph nodes in the neck or the lesions in the ribs and the clavicles were not examined microscopically but, in view of their striking resemblance to the osseous lesions of multiple myeloma together with the presence of Bence-Jones proteinuria, it is presumed that they were of this nature. One cannot, of course, state definitely that the osseous involvement was secondary to the tumor of the pharynx but this assumption seems justifiable. The comparative inactivity of the pharyngeal neoplasm and the extremely active character of the metastatic lesions are striking. Impressive too is the long symptom-free interval (almost eight years) between the removal of the primary growth and the development of symptoms referable to the secondary deposits. The case strongly emphasizes, too, the questionable prognosis of plasmocytoma and the necessity of refraining



from undue optimism concerning the ultimate prognosis even though there is no evidence of recurrence after the lapse of several years.

In the light of our experience with this group of 11 cases of plasma cell myeloma it is difficult to comprehend many of the statements appearing in textbooks of pathology and in articles on this subject in the current medical literature. Unquestionably, this type of tumor is rare and there can be no doubt concerning the malignancy of the ones that we have seen. The two plasma cell tumors encountered in the pharynx occurred among approximately 360 malignant neoplasms in this region; the two present in the nasopharynx were found among more than 300 malignant growths in this situation. We have observed approximately 625 cases of malignant growths of the nose and accessory sinuses during the past 14 years, yet among these there were only six cases of plasma cell myeloma. Among more than 1,600 malignant neoplasms of the larynx seen at the Clinic there has been but one case of plasma cell myeloma. In view of this, is it any wonder that one pauses in amazement over the statement appearing in a recent edition of a standard textbook on pathology; namely, that these tumors are comparatively frequent in the nasopharynx, alveolar borders, tongue, lips and cervical lymph nodes.<sup>7</sup> Geschickter,<sup>8</sup> in a paper on "Tumors of the Nasal and Paranasal Cavities," designated one group of neoplasms as "benign and malignant plasmocytomas," and stated that in the majority of cases of benign plasmocytoma in his series the tumors undoubtedly were inflammatory in type. The same cannot be said of the tumors found in our series. Although they have varied greatly in their activity, some of them being fulminating malignant tumors and others only mildly malignant, all of them were true neoplasms. Microscopically, these neoplasms, regardless of their situation, present a picture that tends to uniformity. The neoplastic plasma cells are usually diffusely massed like the cells of a lymphosarcoma but they also may present a single file effect comparable to the cells of certain carcinomas of the breast and the stomach. There was not the remotest suggestion that any of these tumors were granulomatous or inflammatory. On the basis of our experience, we believe that plasmocytomas are malignant lesions and that they should be classified and treated as such.

MAYO CLINIC.

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IRRIGATION OF THE MAXILLARY SINUS BY WAY OF  
THE MIDDLE MEATUS

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The middle meatal approach to the maxillary sinus for purposes of irrigation is rapidly gaining favor as more and more rhinologists become acquainted with the advantages of this route over that of the inferior meatus.

Many, however, still cling to the inferior meatal approach as they originally learned it and have never experienced the ease and simplicity with which an antrum may be irrigated through a readily accessible ostium.

Those attempting to catheterize the maxillary ostium for the first time are often discouraged from developing a technic because of the anatomic barriers which are likely to confront them. The nature of these barriers was described in a previous article by the writer<sup>1</sup> in 1936. It was pointed out at that time that the approach to the maxillary ostium was impossible or difficult of attainment in many cases because of a bulky or low-hanging middle turbinate, an overhanging ethmoid bulla, a high uncinate wall, a narrow hiatus semilunaris or a deviated nasal septum. Examples of these various anatomic barriers may be observed in an examination of any large series of specimens from cadavers.

In such an anatomic study it may be observed that in approximately 55 per cent the maxillary or an accessory ostium is readily available for catheterization, in 30 per cent it may be reached but with difficulty, while in the remaining 15 per cent the ostium is entirely inaccessible.

In a majority of cases, then, irrigation of the antrum may be carried out by way of the normal ostium without difficulty and with little annoyance to the patient, and this alone should justify a wide-

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Fig. 1.—The membranous naso-antral wall. This area varies considerably in size and shape in different individuals. In the specimen illustrated, transillumination reveals a fairly normal membranous area. Arrow points to the preferred site of puncture just above the inferior turbinate near the junction of its middle and posterior thirds.

Fig. 2.—Small membranous area, due to a misplaced posterior ethmoid cell. The specimen illustrated reveals the importance of keeping puncture point low in the middle meatus. *e*—Posterior ethmoid cell which extends medially into the nasal cavity.

spread adoption of the procedure. Clinicians who follow the technic routinely become adept and are successful in many cases which present insurmountable barriers to the inexperienced. Prolonged search for an elusive opening, however, is not advocated, regardless of the operator's experience or skill. Excessive manipulation in the neighborhood of the ostium traumatizes the mucosa and may add to the congestion of the membranous lining of the ostium, producing, thereby, damage which more than offsets the benefits derived from the sinus lavage.

On the other hand, cannulation of an easily accessible opening when adroitly carried out causes no more harm than the ordinary nasal pack such as is commonly used for various purposes by all rhinologists. In those patients with an ostium not so easily reached, puncture of the naso-antral wall is indicated. This may be carried out in

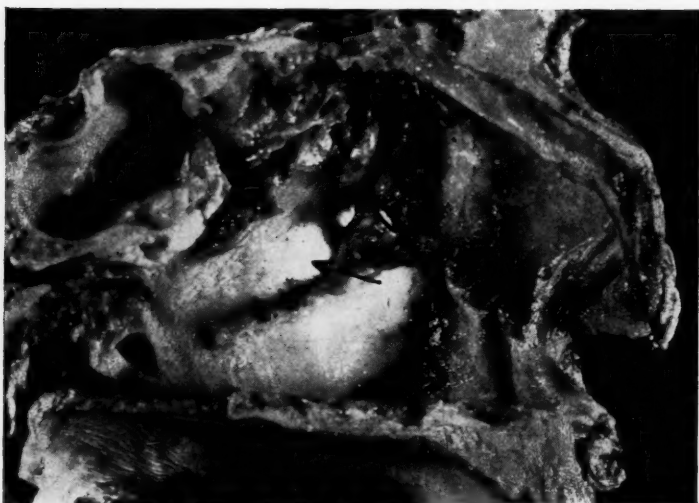


Fig. 3.—Small puncture area indicated by arrow. In the specimen illustrated the attachment of the inferior turbinate (*i.t.*) occupies a high position on the lateral wall encroaching on the middle meatus. Transillumination reveals the thin bone in the vault of the inferior meatus. Marker in maxillary ostium.

the inferior meatus through the bony wall or through the membranous portion (nasal fontanelle) of the middle meatus. Rosenberger<sup>2</sup> adopted the plan of anesthetizing both areas at the same time; then in case he failed to locate the normal opening he resorted to puncture of the inferior meatal wall without further preparation. This method is undoubtedly an improvement over the old standard puncture technic which did not include a preliminary attempt at catheterization of the ostium. With this technic at least half the patients undergoing antral lavage are spared the pain and annoyances which usually attend the procedure of penetration of the bony naso-antral wall.

Still further improvement in irrigation technic calls for the use of the middle meatus exclusively.

This method is not new; it was in reality described 60 years ago, two years previous to the adoption of the inferior meatal approach. Hartman,<sup>3</sup> credited with being one of the first to irrigate the antrum, wrote in 1885 that he was able to sound the maxillary ostium in cer-



Fig. 4a.—Cannulas in maxillary ostium and membranous area. The cannulas are separated by the uncinate process, unusually long in the specimen illustrated.

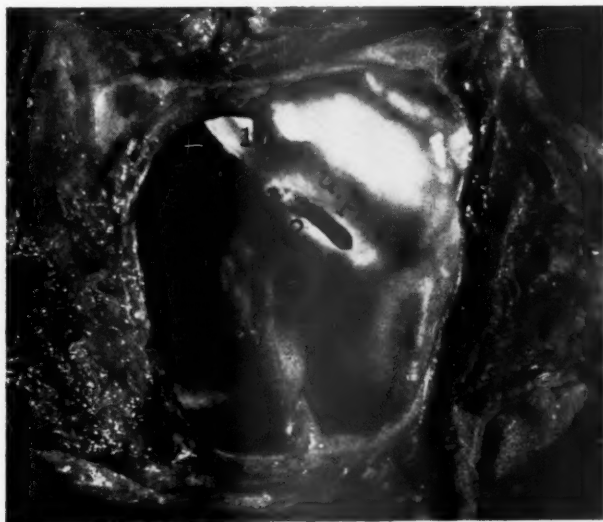


Fig. 4b.—Antral side of specimen showing cannula tips in the maxillary ostium and membranous areas.



Fig. 5a.—Cannulas in maxillary ostium, 1, and membranous area, 3, and a Lickwitz needle in the inferior meatus, 2. Transillumination shows the membranous area to be somewhat larger than usual.

Fig. 5b.—Antral side of specimen showing the tips of the three instruments in the sinus lumina. The inferior meatal needle, 2, is shown in its usual position high on the antral wall and actually nearer the ostium, 1, than the point of perforation through the membranous area, 3.

tain cases and in the others he passed a cannula through the membranous portion of the middle meatus. The method, however, for some reason not explained had few followers and most rhinologists accepted the inferior meatal approach of Mikulicz. His procedure described in 1887<sup>4</sup> was a welcome substitute for the method of Cowper, in vogue at the time, which often necessitated the removal of a tooth.<sup>5, 6</sup>

The technic which now removes the need of bony puncture in antral irrigation is described as follows: The middle meatus alone is anesthetized. The membranous area is probed carefully for an accessory opening. The cannula tip is brought forward into the hiatus semilunaris between the bulla and the uncinate process. As the space between these two structures narrows down, the tip is rotated downward and should pass into the normal ostium. This contact is prevented if the hiatus is too narrow at the point adjacent to the opening, or if a large turbinate prevents rotation. In any event, little time is spent in probing; the dull-tipped cannula is exchanged for one



with a sharp point and the membranous wall is penetrated without further ado.

This method used routinely simplifies antral lavage to the point of almost complete elimination of the distressing factors otherwise associated with the procedure.

There are rhinologists, however, who, as stated previously, rely entirely on the inferior meatus when perforation of the naso-antral wall is indicated. They have never made use of the membranous area for this purpose, the reasons being: (1) they are satisfied with the inferior meatal approach and hesitate to attempt a technic with which they are not familiar; (2) they fear the consequences of a misplaced cannula tip, such as air embolism, emphysema, injection of solution or air into the orbit or into the ethmoid field with extension of infection to these areas; and (3) they hesitate to place an opening near the ostium which might cause an interruption in the continuity of the mucociliary stream.

*Comment.* Sinus irrigation, although apparently a simple, harmless, office procedure, should never be regarded as being entirely free of possible mishaps regardless of the area of approach or the technic used. It is true that certain of these mishaps occur in the middle meatus, yet a far more imposing list of complications, including those with bone involvement, result from perforation of the bony naso-antral wall.<sup>7, 8</sup>

Grove<sup>9</sup> in 1922 collected from the world's literature 15 case reports of fatalities following antral puncture and irrigation. In seven, the point of perforation was the inferior meatus; in three the middle meatus, while in the remaining five the area of puncture was not mentioned. He also collected 25 case reports in which the symptoms were serious but the patients "escaped with their lives." In this group 15 received their puncture in the inferior meatus; two in the middle and in eight it was not specified. In most of the 40 cases the cause of the complication was air embolism, brought about by the deliberate injection of air preceding irrigation. This dangerous practice, fortunately, has long been discontinued in most quarters and perhaps for that reason reports of fatalities following antral puncture are not found in the modern literature.

The question of injury to the sinus mucosa near the ostium arises. This is an important consideration, yet proper technic eliminates the possibility of such injury. The sharp-pointed instrument is not intended for use in the infundibulum. It is best kept below the un-

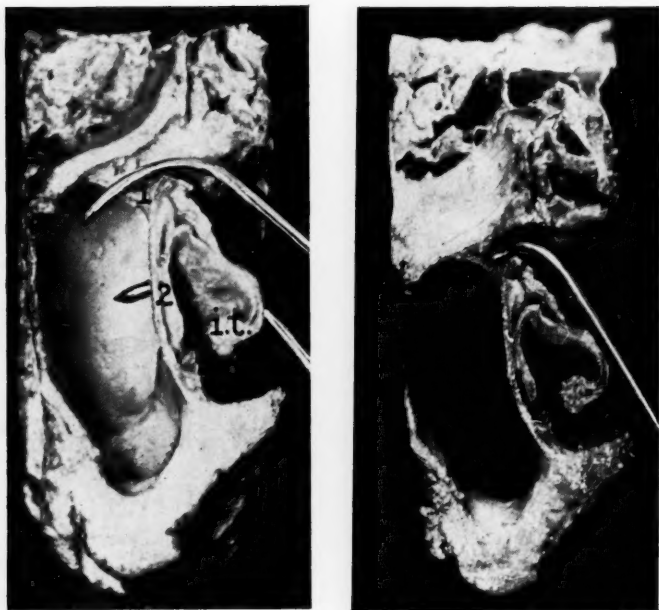


Fig. 6.—Frontal section of a specimen showing cannula 1, in maxillary ostium; cannula 2, in membranous area.

Fig. 7.—Short tipped cannula in infundibulum. Lavage of the sinus is possible even though the cannula tip has not passed through the ostium.

cinat process and the usual point of penetration is just above the superior border of the inferior turbinate near its posterior third.

The opening made by this instrument is scarcely more than 2 mm. in diameter and heals quickly. There is little likelihood of permanent injury to the sinus lining resulting from this type of opening unless the area is perforated repeatedly in a short space of time.

*Application of Irrigation Technic.* Irrigation of a sinus, regardless of the method of approach, is an effective therapeutic measure in certain types and stages of sinus disease.

It is not used during the early stages of an acute attack. In the presence of acute congestion, sinus lavage is not only ineffective but detrimental and may even prove to be dangerous. In the later stages, however, with the establishment of active immunity and the reces-

sion of tissue edema, irrigation is a safe, effective measure and in many cases is the factor responsible for the termination of a condition which otherwise would have progressed to a state of chronicity.

In chronic infections sinus irrigation is generally regarded as of little value. This may be true when it is used as the sole therapeutic measure. Its value in these cases, however, is outstanding in the manner in which it serves as an aid to diagnosis.

When confronted with a persistent maxillary sinus infection, the rhinologist often includes with his diagnostic measures a roentgen study with iodized oil in the sinus. In his management of the case he attempts an early restoration of adequate drainage through the natural pathways, if possible. To accomplish this may require septal resection, middle turbinate infraction, removal of polyps and the control of allergy. In the meantime, progress of the case may be noted by periodic sinus irrigations with the instillation of oil for check-up films.

Proper management of a persistent sinus infection, then, along with the correction of drainage defects, may require several irrigations. These serve the dual function of ridding the cavity temporarily of accumulated secretions and casting light on the progress of the disease.

The manner in which these irrigations are carried out often has considerable bearing on the extent of cooperation to be expected from the patient. Certainly the ordinary individual will submit readily and repeatedly to a simplified form of antral lavage but will not enthruse over the prospect of a series of perforations through the bony naso-antral wall and may well give up long before this form of therapy has been given a fair trial.

#### SUMMARY

The middle meatal approach to the maxillary sinus for the purpose of irrigation is rapidly gaining favor as more and more rhinologists become acquainted with the advantages of this route over that of the inferior meatus.

The maxillary or an accessory ostium is available for catheterization in a majority of cases and this fact alone should justify a widespread adoption of the procedure.

The technic advocated calls for the use of the middle meatus exclusively in antral lavage and this in large measure eliminates the distressing features of the procedure as it is usually carried out. In

this approach a search is first made for an accessory opening, then for the maxillary ostium. In the event that no opening is found readily a sharp-pointed cannula is pushed through the membranous portion of the naso-antral wall. The site for puncture is just above the inferior turbinate slightly posterior to the midline.

Objections to the middle meatal approach are raised, yet, similiar objections with the addition of others apply to the inferior meatal approach.

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## XXVI

### THE RESPIRATORY FUNCTION OF THE LARYNX

#### SOME OBSERVATIONS ON LARYNGEAL INNERVATION

##### PRELIMINARY REPORT

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In general there are two functions of the larynx — first, its actions as a valve; second, its activity in phonation. We are concerned with the former only. Unanimous agreement as to individual muscle function, as to laryngeal innervation and as to laryngeal nerve sensitivity is lacking. In an effort to obtain graphic representation of laryngeal nerve response in thyroidectomy, we have developed an apparatus which we feel will record changes in intralaryngeal volume in the living animal. In the utilization of this procedure we have attempted to obtain records of individual muscle function and of the function and sensitivity of the superior and the recurrent laryngeal nerves. We are presenting some of our findings as a preliminary report in an attempt to demonstrate this method as a means of studying laryngeal function.

The valvular function of the larynx has been investigated by Longet,<sup>11</sup> Wyllie,<sup>27</sup> Brunton and Cash,<sup>2</sup> Semon,<sup>23, 29</sup> Semon and Horsley,<sup>30</sup> Negus<sup>12</sup> and recently Pressman.<sup>18</sup> An excellent bibliography is given by Semon. Since Wyllie's paper in 1866 investigators have been generally in agreement as to the valvular function of the larynx. There still exists some controversy in regard to laryngeal innervation. This difference of opinion has arisen partly from an attempt to explain and correlate the clinical picture seen in laryngeal paralysis with the findings of investigators in the late nineteenth century, and in more recent times with the anatomic studies such as those of Berlin and Lahey,<sup>1</sup> Nordland<sup>15</sup> and Ziegelman.<sup>28</sup> Recent investigators have attributed a motor function to the internal branch of the superior laryngeal nerve in an attempt to explain the adduction of the

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This work was done in association with Dr. Clarence J. Campbell, Department of Physiological Sciences, Dartmouth Medical School.

Presented as a candidate's thesis to the American Laryngological, Rhinological and Otological Society.

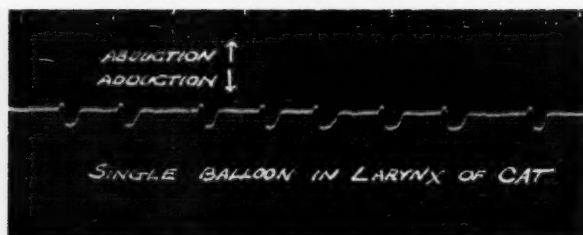


Fig. 1.—3/25/43. Cat. Urethane anesthesia. Foley catheter in larynx. Normal curve. The upward movement of the shadow represents abduction; the downward movement, adduction of the vocal cords.

vocal cords following injury to the recurrent laryngeal nerve. Lemere<sup>8, 9</sup> has reviewed this controversy and has done considerable anatomic and experimental work in an effort to definitely establish the facts. His findings have been in agreement with those of Ónodi,<sup>16</sup> whose ideas in regard to laryngeal innervation have been generally accepted. A recent tendency has developed to deviate from these established principles and to theorize without regard to the complete and exhaustive work of those men whose findings should be considered with great weight in any clinical discussion of laryngeal paralysis. We feel that we are able to substantiate and graphically illustrate a number of the principles previously established by Ónodi and Lemere by obtaining graphic records of muscle response to muscle and to nerve stimulation.

Dionisio<sup>4</sup> reported dynamometric measurements of the pressure within the larynx of experimental animals. Neumayer<sup>13</sup> reported manometric studies on the pressures within the human larynx. Both investigators recorded pressures as read on a mercury manometer and so far as we have been able to find made no graphic records. Hooper,<sup>5, 6</sup> working with Prof. Bowditch at Harvard, secured graphic records of the movements of the laryngeal cartilages on stimulation of the external branch of the superior laryngeal nerve. Wagner<sup>25, 26</sup> secured photographs of the changes in position of the vocal cords in dogs after section of the various laryngeal nerves. Réthi<sup>19-22</sup> reported on the mechanism of the pharyngeal voice and showed numerous photographs of the larynx during various phases of activity of the glottis.

*Method.* Our first experiments were done on cats. Windows were made in the larynx; and on stimulation of the laryngeal nerves, action of the vocal cords was observed. We noted that the recur-

rent laryngeal nerves of cats were extremely sensitive and that often a moderate mechanical stimulus would produce a marked contraction of the corresponding vocal cord. We thought that it might be interesting to obtain graphic records of the changes in the glottic picture on stimulation of the laryngeal nerves. Accordingly, a Foley retention catheter, in which the balloon had been replaced by more delicate rubber, was placed in the larynx of the cat, the balloon was connected to a sensitive tambour and the changes in the volume in the larynx recorded photographically (Fig. 1). Because of the size of the cat's larynx and because of the apparent difference in sensitivity of the recurrent laryngeal nerve in the cat and in the dog,<sup>7</sup> we decided to use larger animals and we chose the goat. The larynx of the goat seemingly more closely approximates the human larynx in size and appearance; and, on dissection of the laryngeal nerves, it seemed to resemble the human larynx even more closely than does that of the dog. In our dissections to date we have found no median nerve.

A balloon was placed about a rigid airway, and the proximal end of the airway was fitted with an adaptor which could be used on a standard anesthesia machine (Fig. 2). To further immobilize the airway, a more distal balloon was added later. This was not connected to the recording system but was merely added as an anchor for the instrument. The proximal end of the instrument was fixed by placing it in a slot in a mouth gag. The recording balloon was connected by heavy wall tubing to a water manometer and a Marey tambour mounted vertically in front of the camera of an old-fashioned string galvanometer electrocardiograph (Fig. 3a). A side arm could be connected for inflation and for establishing pressure within the system adequate to give optimum movement of the tambour lever (Fig. 3c). Other tambours were placed in front of the camera and used to record simultaneously both intratracheal pressure and the movement of thoracic or abdominal pneumographs (Fig. 3b). When the double balloon was used in the glottis, each balloon was connected to a separate tambour and the remaining tambour was used to record intratracheal pressure. The introduction of such an apparatus and the inflation of the balloons undoubtedly cause changes in the character of respiration, particularly if the balloons are inflated to a pressure of 10 to 12 cm. of water.<sup>17</sup> Pentobarbital sodium was used in most experiments as a preliminary anesthetic and was substantiated with ether. In some experiments we used pentothal sodium intravenously.

After the apparatus was introduced, the animals were operated on under aseptic precautions. The various laryngeal nerves and



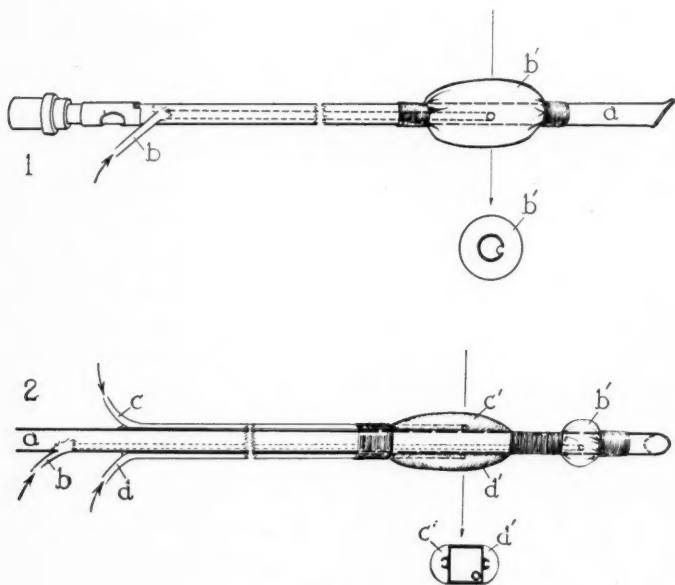


Fig. 2.

1. Single balloon apparatus. *a* airway, *b'* balloon, *b* tube connecting balloon to recording system.

2. Double balloon apparatus. *a* airway, *b'* distal balloon, *b* tube for inflating distal balloon, *c'* and *d'* right and left balloons, *c* and *d* tubes connecting balloons to the recording system.

muscles were exposed and dissected free for further experiment. At the end of each experiment the wounds were closed, and in most cases the animals were preserved for further observation and further use.

**Results.** The usual type of record which is obtained using the single and the double balloon airways is shown in Figs. 4 and 5. In these records, as in all that are shown, the respiratory tracings are so arranged that in recording intratracheal pressure inspiration records in a downward direction, and in the pneumographic tracings from the chest or the abdomen inspiration is indicated by an upward movement of the shadow. The laryngeal apparatus is so arranged that abduction of the cords or enlargement of the glottis is represented by an upward movement of the shadow. All points which lie on the same vertical line are synchronous.

Stimulation of the recurrent laryngeal nerve produces the type of record shown in Figs. 6, 7 and 8. From these and from similar records it appears that there are no afferent fibers in the recurrent. Stimulation of the central end of the cut nerve produces no changes which are recorded by the apparatus. Stimulation of the peripheral end of the cut nerve produces abrupt adduction which is confined to the side stimulated. The slight change on the nonstimulated side in Fig. 8 we have considered to be due to the displacement of the entire airway to that side by the adduction of the stimulated side. The addition of the distal anchor balloon cut down this excursion very definitely. Without the distal balloon there was very little difference in the movement of the shadows on the stimulated and on the nonstimulated sides. The slight change in respiration in these records appears only when the peripheral end of the nerve is stimulated and may be due to reflex changes brought about by stimulation of the endings of the superior laryngeal nerve, internal branch, by changes in the glottic pressure.<sup>17</sup> In several experiments we have secured records such as that shown in Fig. 9 on sectioning the recurrent nerve. This is the best graph that we have of the apparent transient loss of tone and of vibration of the vocal cord innervated by the cut nerve. This may represent the changes which have been observed visually during total laryngectomy.<sup>3</sup> The previous section of the internal branch of the superior laryngeal in the particular instance shown we consider to be of no significance.

Stimulation of the internal division of the superior laryngeal nerve in its course at the point where the nerve enters the thyrohyoid membrane results in an opening and closing movement of the glottis and in marked changes in respiration. (Cessation in Fig. 10). Following section of the internal branch of the superior laryngeal nerve, stimulation of the central end is followed by swallowing movements and changes in respiration. Fig. 11, using the double balloon, illustrates these changes. Both the glottis and respiration are affected, but in this case respiration is not stopped and short inspiratory gasps replace the normal rhythm. Stimulation of the peripheral end of the cut internal branch is quite without effect on either glottis or respiration (Fig. 12). This has been repeated many times and at no time could we find evidence of motor function in the internal division of the superior laryngeal nerve. A ligature on this nerve produces a transient change in respiration without noteworthy changes in the glottic record (Fig. 13).

Our experiments on stimulation of the various muscles of the larynx have shown to date nothing of particular interest except in

Fig. 3a.—Diagram of Recording Apparatus. *a* light source, *b* condensing lens, *c* Marey tambour, *d* camera as seen in section.

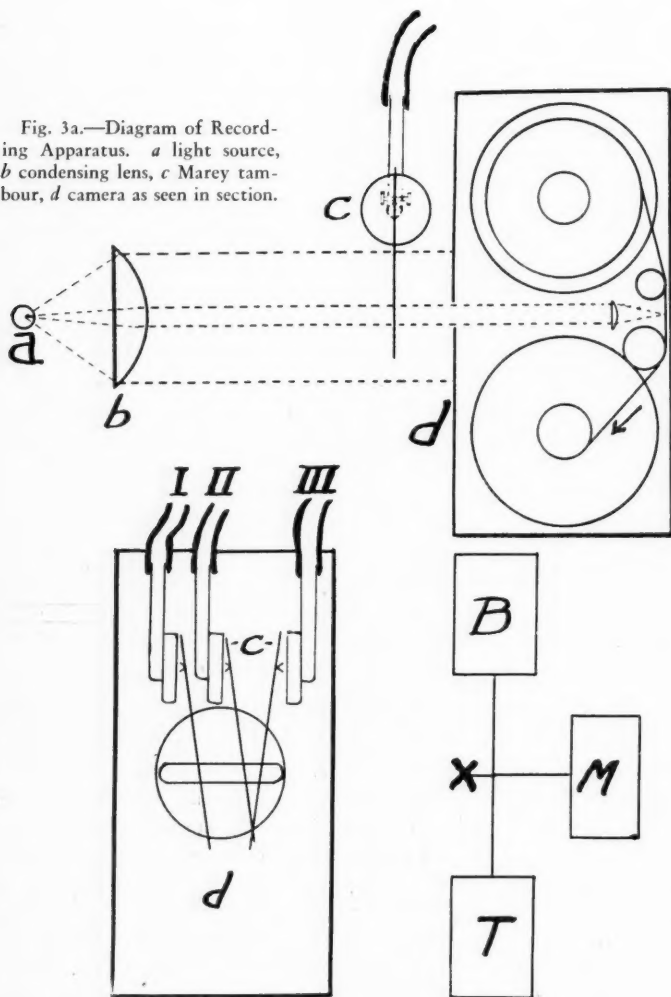
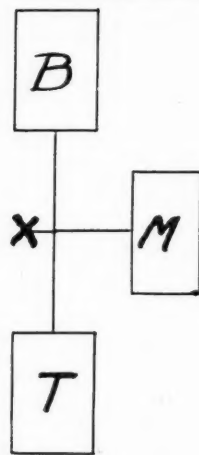


Fig. 3b.—Diagram of camera as viewed from the light source. *c* Marey tambours, *d* camera, I, II and III heavy walled tubes to glottic balloons and pneumograph.

Fig. 3c.—Scheme of Recording System. *B* glottic balloon, *T* tambour, *M* water manometer, *X* side arm for inflating system.



the case of the cricothyroid. Here (Fig. 14) there is evidence that the cricothyroid is a strong adductor.<sup>9, 16</sup>

This adductor action of the cricothyroid (more properly the thyrocricoid<sup>5, 6</sup>) leads to some speculation on the role that this muscle plays in the laryngeal picture presented in recurrent nerve paralysis. With this in mind an experiment was done on an animal in whom both recurrences and both internal branches of the superior laryngeal had been sectioned and a tracheotomy performed. Because of extensive scar tissue formation (the operations extended over a period of months) it was impossible to conveniently isolate and section the external branch of the superior laryngeal nerve. The same result was, however, achieved by sectioning the vagus above the nodose ganglion as the only efferent fibers running to the larynx that remained were those of the external branch of the superior nerve. The glottis previous to this operation showed the vocal cords nearly approximated in the midline, except for a triangular posterior chink. Following section of the left vagus (Fig. 15, upper glottic tracing) the left cord apparently moved in the direction of abduction and remained there. A similar, more abrupt change followed section of the right vagus (Fig. 16, lower glottic tracing). The right cord shifts permanently to a position of abduction. The results were also visible on laryngoscopic examination. The complete set of experiments on this animal would indicate that the midline position of the vocal cords, with an inadequate airway, follows complete bilateral section (paralysis) of the recurrent nerves; the movement of the cords laterally (cadaveric position) follows only when the only remaining adductor, the thyrocricoid muscle, is paralyzed by sectioning or blocking the external branch of the superior nerve.<sup>10, 24, 25</sup>

#### SUMMARY

We are making a preliminary report of typical results and records obtained by the introduction of a pneumatic recording device in the glottis of experimental animals, mainly goats, and of the results obtained by stimulation of the laryngeal nerves and some of the intrinsic muscles of the larynx. Records pertaining to recurrent nerve sensitivity as related to thyroidectomy we hope to present at a later date.

#### CONCLUSIONS

1. We are able to find no evidence of motor function in the internal branch of the superior laryngeal nerve of the goat, nor is there any evidence of reflex changes following stimulation of the central end of the cut recurrent laryngeal nerve.

2. The internal branch of the superior laryngeal nerve carries afferent fibers involved in various reflexes, affecting glottic motion and altering respiration.

3. The cricothyroid muscle, or the thyrocricoid as it should more definitely be called, has a marked adductor function, a fact previously emphasized by Wagner, Ónodi, Lemere and recently Iglauer. This muscle is responsible for maintaining the cord in the so-called median or paramedian position following complete recurrent laryngeal nerve paralysis.

4. Experimental evidence and visual observation indicates that following section of both recurrent laryngeal nerves, elimination of the function of the external branch of the superior laryngeal nerve produces a marked abduction of the vocal cords, increasing the laryngeal airway.<sup>25</sup>

5. An increase in laryngeal pressure alters the character of respiration.

6. In our experiments we have merely substantiated graphically previous facts emphasized by Ónodi and Lemere and others.

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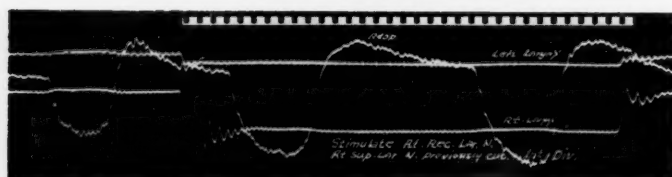
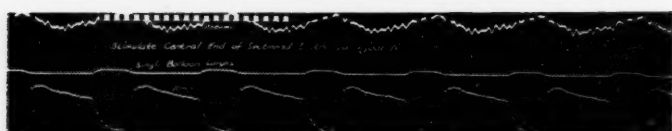
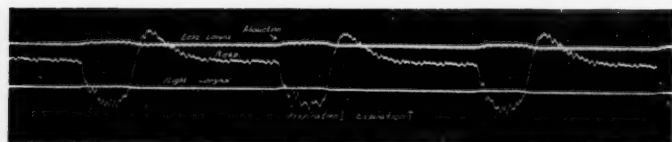
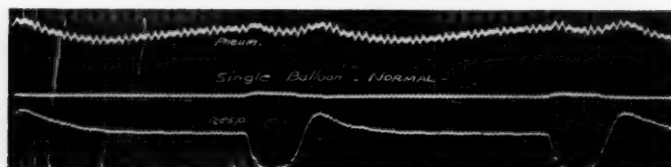




Fig. 4.—Single balloon in larynx. Anesthesia, pentobarbital sodium and ether. Normal curve. The upper tracing is that of the pneumograph. Inspiration is indicated by its upward movement. The middle tracing is the laryngeal curve. The upward movement represents abduction of the vocal cords. The lower tracing represents intratracheal pressure. Inspiration is recorded by its downward movement.

Fig. 5.—Double balloon in larynx. Anesthesia, pentobarbital sodium and ether. Normal curve. The upper laryngeal curve represents the left vocal cord; the lower curve represents the right vocal cord. Abduction of both vocal cords coincides with the beginning of inspiration as recorded by the curve representing intratracheal pressure.

Fig. 6.—Goat No. 8, 9/21/43. Single balloon in larynx. Anesthesia, pentobarbital sodium and ether. Stimulation, faradic current, peripheral end of sectioned left recurrent laryngeal nerve. The laryngeal curve is in adduction throughout the period of stimulation.

Fig. 7.—Goat No. 8, 9/21/43. Stimulation of central end of sectioned left recurrent laryngeal nerve. No change is recorded by the apparatus. There is no evidence of afferent fibers in the recurrent.

Fig. 8.—Goat No. 4, 9/14/43. Double balloon in larynx. Anesthesia, pentobarbital sodium and ether. Right superior laryngeal nerve, internal division, previously sectioned 4/27/43. Stimulation right recurrent laryngeal nerve, faradic current. An abrupt adduction of the vocal cord on the stimulated side occurs. The slight change on the nonstimulated side we have considered to be due to the displacement of the entire airway to that side by the adduction of the stimulated side. The addition of the distal balloon cut this excursion very definitely.

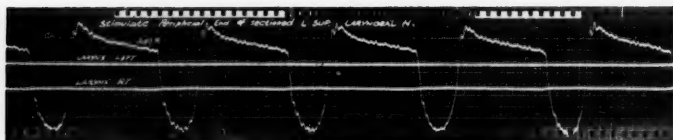
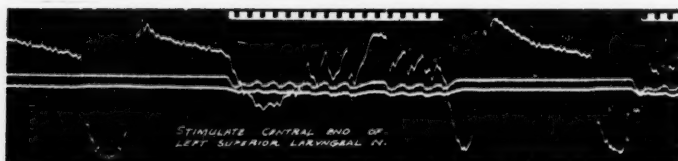
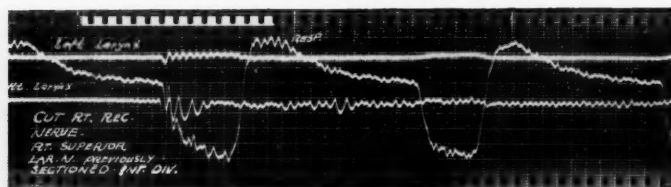


Fig. 9.—Goat No. 4, 9/14/43. Double balloon in larynx. Anesthesia, pentobarbital sodium and ether. Right superior laryngeal nerve, internal division, previously sectioned 4/27/43. Right recurrent laryngeal nerve cut. The lower glottic tracing represents the apparent transient loss of tone and of vibration of the vocal cord innervated by the cut nerve.

Fig. 10.—Goat No. 8, 9/28/43. Single balloon in larynx. Anesthesia, pentobarbital sodium and ether. Left superior laryngeal nerve, internal branch, exposed and stimulated, faradic current, at point of entrance to the thyrohyoid membrane. There is complete cessation of respiration and a marked opening and closing of the larynx.

Fig. 11.—Goat No. 7, 7/20/43. Double balloon in larynx. Anesthesia, pentobarbital sodium and ether. Stimulate (faradic current) central and left superior laryngeal nerve, internal branch, on signal. Right superior laryngeal nerve, internal branch, cut 5/6/43. In this instance the opening and closing of the larynx is associated with pronounced changes in respiration, but not cessation.

Fig. 12.—Goat No. 7, 7/20/43. As in Fig. 11. Stimulate (faradic current) peripheral end of left superior laryngeal nerve, internal branch, on signal. There is no effect on either the glottis or respiration. There is no evidence of motor function in the internal division of the superior laryngeal nerve.

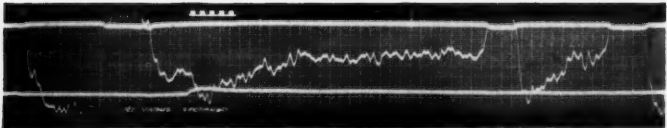
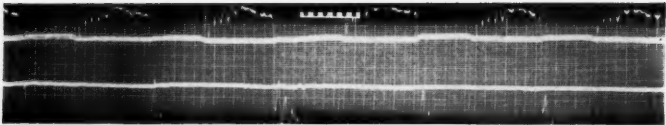
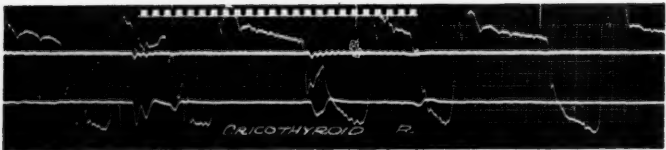
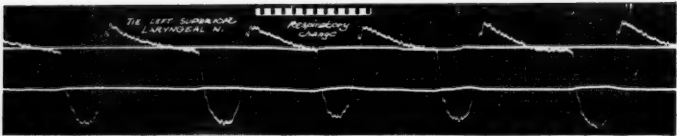


Fig. 13.—Goat No. 7, 4/20/43. As in Figs. 11 and 12. Tie left superior laryngeal nerve, internal branch, on signal. A transient change in respiration occurs without change in the glottic record.

Fig. 14.—Goat No. 4, 10/26/43. Double balloon in larynx. Anesthesia, pentobarbital sodium and ether. Right superior laryngeal nerve, internal division, cut 4/27/43; right recurrent laryngeal nerve cut 9/14/43; left recurrent laryngeal nerve cut 9/14/43; tracheotomy 9/14/43. Stimulate cricothyroid muscle, right, galvanic current, indifferent electrode over lumbar spine, stimulating electrode cathode. Stimulation during signal—make, break make, break. Lower glottic tracing from right balloon. Pronounced adduction occurs.

Fig. 15.—Goat No. 4, 1/6/44. Anesthesia, pentobarbital sodium and ether. Right superior laryngeal nerve, internal branch, cut 4/27/43; left superior laryngeal nerve, internal branch, cut 11/30/43; right recurrent laryngeal nerve cut 9/14/43; left recurrent laryngeal nerve cut 9/14/43; tracheotomy 9/14/43. Airway inadequate without tracheotomy tube. On section of the left vagus, the vocal cord moves in the direction of abduction and remains there. (Upper glottic tracing)

Fig. 16.—Goat No. 4, 1/6/44. Anesthesia, pentobarbital sodium and ether. Right superior laryngeal nerve, internal branch, cut 4/27/43; left superior laryngeal nerve, internal branch, cut 11/30/43; right recurrent laryngeal nerve cut 9/14/43; left recurrent laryngeal nerve cut 9/14/43; tracheotomy 9/14/43. Airway inadequate without tracheotomy tube. Right vagus sectioned. The right vocal cord moves abruptly in abduction and remains there. (Lower glottic tracing)

## XXVII

### A SIMPLE AND PRACTICAL PROCEDURE FOR DEVELOPING ESOPHAGEAL VOICE IN THE LARYNGECTOMIZED PATIENT

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RICHMOND, VA.

The incidence of laryngeal cancer is much greater than mortality statistics indicate. It is estimated that four per cent of all malignant tumors of the body occur in the larynx, and that only one and one half per cent of cancer deaths are due to lesions of this organ.

As total extirpation of the larynx is performed more and more often, it becomes necessary that the laryngologist interest himself more and more in the problem of esophageal speech. In the past decade the literature pertaining to laryngeal malignancy has been very extensive. However, with few exceptions little consideration has been given to the development of voice in the patient without a larynx. The immediate training and production of a pseudovoice in a laryngectomized person is now recognized as an integral part of the management of this disease, and the patient may not be completely dismissed until every possible opportunity has been given to acquire a new speech.

It is often stated that cancer of the larynx is on the increase, and that approximately 80 per cent of such lesions originate on the vocal cords, and in most instances give adequate warning.<sup>1</sup> If this statement is true a much larger number of early cases should be seen by the laryngologist than are being seen to-day. According to some authors laryngectomy is performed three times as often as laryngofissure. It is generally conceded, however, that only 20 per cent of persons with laryngeal malignancy when examined are suitable for laryngofissure, while 40 per cent require total extirpation, and that the rest may be regarded as inoperable. The layman can easily diagnose hoarseness and the laryngologist can just as easily analyze the cause of the symptom; yet, malignant cord lesions are too infrequently seen until the danger signal has lost most of its virtue.

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Read before the meeting of the Southern Section of the American Laryngological, Rhinological and Otorological Society, Charlotte, N. C., Jan. 15, 1945.

The question may be asked, is not life expectancy short after laryngectomy? The answer is quite relative. Age and body condition apart from the cancer are important factors. The immediate operative mortality is low, though conversely the recurrence incidence is estimated at 50 per cent. This, of course, varies with the individual operator's criteria used in selecting patients for operation. When the lesion requires total extirpation of the larynx and the patient is so informed, he not only thinks of the operative risk and the uncertainty of being permanently cured, but also of the total loss of his voice. While this phase of the situation is secondary, it is a most important consideration to the patient. Until it is explained in detail that a new way of talking can be developed, he is profoundly affected.

The laryngologist of course gives more thought to the diagnosis and extirpation of cancer than he does to restoring the function that the organ performed. It has only been in recent years that a few American laryngologists have made a concerted effort to restore to these patients a voice which may be his own. In many instances the physician may feel that his responsibility is ended when he discharges the patient from the hospital and requests that he use an artificial voice box. A large number will do this and make the best of it, while others will be too sensitive or discouraged to avail themselves of its use.

The artificial larynx is serving a good purpose in many instances. However, when it is considered in conjunction with esophageal speech, the disadvantages are too numerous to elaborate upon in this paper. Jackson received 30 replies to questionnaires sent laryngectomized patients, and to these only 18 replied "yes" to the question, "Have you learned to speak without your larynx?"<sup>2</sup> Wright stated in a splendid paper published in 1942 summarizing ten laryngectomies, "One patient has developed an excellent stomachic voice, and the others have an audible and understandable whispered voice. All have learned to use the artificial larynx."<sup>3</sup>

Curing the patient is of course first consideration in dealing with cancer. However, voice development is of considerable concern to the patient if he attempts to regain his former economic and social station in life. When the patient leaves the hospital, he is usually cheerful and grateful, but I am sure in a deeper sense he is profoundly impressed with the fact that he is isolated from normal social life and unsuitable for employment. The first problem is to rehabilitate the patient psychologically, and second, physically.

There are on record certain ingenious patients who have produced good vicarious voices, either by chance or self-instruction.





Fig. 1.—Showing method of piping air into the esophagus.

Conversely, there are others who have extreme difficulty in grasping the idea of vocal gymnastics, and are unable to perform the action in an effective manner. There are several factors which influence the development of esophageal voice: (1) the will of the patient to learn, which is especially essential, and (2) the encouragement and confidence that may be imparted to the patient by one who has had a like operation and has acquired a satisfactory voice. The psychology of voice production is an interesting study and perhaps it is based upon conjecture and results in an unknown quantity. Our present knowledge of nerve control of involuntary action is also necessarily limited.

It is not entirely clear what influence operative technic has upon a substitute voice. Gutzmann<sup>6</sup> thinks the voice is largely dependent upon the individual anatomic construction of the upper esophagus and hypopharynx. Stern<sup>7</sup> says, "The glottis location probably depends upon the conditions created in the operation, and is of great importance to the success of speech." Total extirpation of the epiglott-

tis has not been seen to exact any unfavorable influence upon voice development, nor has the voice shown any superior quality in those patients whose epiglottis was not removed. In the technic we have followed we have omitted the removal of the hyoid bone. Some operators remove this bone routinely, and I have heard of no adverse effect upon voice development. It does seem that partial resection of the anterior ribbon muscles impairs the antagonistic action of the sphincter fibers of the esophageal orifice. We have had one patient on whom we did a laryngofissure and later a laryngectomy. The anterior ribbon muscles were partially removed because of recurrence and leakage through the cartilage. This patient had much more difficulty in developing a voice than did the average patient, in spite of his enthusiasm and determination. Another patient who had a postcricoid lesion and required partial resection of the upper esophagus in addition to the laryngectomy has as a result a very restricted esophageal lumen. She is acquiring esophageal voice and it will be interesting to note the end result.

The physical requirements for a substitute voice are an air chamber and a glottis capable of vibrating. It is possible that different patients may develop a new glottis in different areas. However, an esophageal orifice should lend itself well to the necessary contracting mechanism of which adjacent structures may be less capable. It occurred to me that if air could be piped below the "would-be glottis" it might aid the patient in forming an air column with sufficient pressure to induce glottic vibrations. Then muscular coordination could be induced by vocal gymnastics. In order to do this a small semi-flexible catheter not larger than a No. 6 is inserted through the nose into the esophagus with its distal end resting in the upper third of the esophagus. The catheter is then anchored to the tip of the nose for placement. By attaching a bulb to the proximal end, air is furnished the esophagus by gentle pressure. My first trial of this method was on a patient who had considerable difficulty in aspirating air or belching. By persistent effort the patient was induced to relax upon prolonged expiration and at the same time compress the bulb rapidly and gently. By repeating this procedure many times sound was eventually attained. I felt encouraged, and so did the patient. He immediately indicated that it helped him develop the sound.

I was then concerned about the possible effect the caliber of the tube would have upon the esophageal vibrators in a finer sense of tone development. So I then summoned a former laryngectomized patient to my office who had achieved an excellent esophageal voice and I tried the experiment upon him. With the catheter inserted in

the esophagus, I learned that there was no change in his tone or articulation. Larger catheters were experimented with later, but they proved to be obstructive. In some beginners I have used a No. 4 catheter with satisfactory results, though I have found that a No. 6 is more effective and it is very well tolerated.

The esophageal glottic folds are assumed to be very flaccid in contrast to vocal cords, and the insertion of a fine catheter does not seem to interfere with their approximation or vibrations. This procedure seems particularly helpful to the beginner until he can at least partially acquire an air chamber or is able to exercise better glottic control. While the tube has a very distinct practical value, it also has a definite psychologic effect. The patient is immediately encouraged when he experiences the sensation that he is definitely aided in making a sound when air is supplied the tissues that are capable of vibrating. This inflow of air is equivalent to esophageal inspiration and its action may be likened to a synthetic lung.

Expiratory pressure serves to help accelerate the column of air during the practice of phonation contractions. By repeated vocal efforts vibratory quality and tension of the soft tissue folds are gradually acquired. During the early process of learning and before voluntary control is demonstrated, the tube serves its greatest usefulness, by supplying air free of effort to the inexperienced glottis, which lacks the help of an organized air chamber. In other words, the use of the tube acts as an artificial air chamber and aids the patient in practice to acquire muscular control. Once this is accomplished the formation of an air chamber below the vibrators should follow. Unpleasant sensations may develop and action may be impeded if too vigorous use is made of the air. During the earliest phase of voice production, the act of supplying the esophagus with air by the patient alone seems to be the most difficult part of acquiring a new speech mechanism. Seemann<sup>4</sup> states, "Once the patient masters the mechanism of voluntary aspiration of air the rest of the speech process is easy." Stetson<sup>5</sup> also says, "Using the constriction of the esophagus is a novel experience, but it does not clash with previous habits of the patient as does this intake process."

Roentgen studies made on certain patients of ours who had acquired a fair degree of esophageal speech, corroborated the observations previously reported by Gutzmann,<sup>6</sup> Morrison,<sup>8</sup> and others, that the constricted esophageal area is the logical tone producing site. The average laryngectomized patient can master a whispered voice without practice or effort. It should be discouraged from the outset, as it makes for faulty habits in developing an understandable speech.

Eructation may be encouraged at the outset and it serves a good purpose in getting the patient started. However, some patients continue the so-called "gastric voice" which is produced by gulping air into the stomach and expelling it with a "clang of a churn." In this instance the act is accompanied by considerable effort and noise. McCall points out that preoperative training in belching is much desired and it will enhance the patients ability to develop a better voice.<sup>9</sup>

The most perfect pseudovoice is usually exhibited by those who develop the nerve cell habit of very frequently inspiring small quantities of air into the esophagus between their words or sentences with no obvious effort. They often attain a fine degree of modulation and frequently a range of one to one and a half octaves. Patients who can acquire such a voice may return to their former station in life with a certain degree of satisfaction.

#### PROFESSIONAL BUILDING.

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## XXVIII

### A NEW TREATMENT FOR ESOPHAGEAL OBSTRUCTION DUE TO MEAT INPACTION

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BOSTON, MASS.

It is well recognized that with the acquisition of an upper denture large masses of meat and fish with and without bone are accidentally swallowed. I wish to discuss those patients who have had meat, without bone, lodge in and obstruct the esophagus. While this mishap occurs in individuals with a normal sized esophagus, it occurs most often in persons with a constricted, or narrowed, esophagus.

You are all familiar with the symptoms of complete esophageal obstruction. The onset is sudden while eating. Thereafter in spite of various homely therapeutic measures the patient is unable to swallow solids or liquids. If the foreign body be lodged low in the esophagus, the patient can fill his esophagus with fluids and partially regurgitate them. If the foreign body be high in the esophagus, fluids spill over into the larynx and cause coughing and choking. Pain may or may not be present; when pain is present, an x-ray examination is a *must* to rule out the presence of bone.

With the diagnosis of meat without bone causing esophageal obstruction, removal is indicated. If the patient is young, nervous, and without esophageal narrowing, morphine sometimes relaxes the normal esophagus sufficiently so that the foreign body slides down into the stomach. If no treatment is given, the meat in time decays. This takes some seven to fourteen days, depending on the size of the piece of meat. If the patient survives without nourishment (unable to swallow liquids or solids) and if the esophagus itself does not become infected, a spontaneous recovery can occur. This is rare! Hitherto, it has always seemed safer to esophagoscope promptly, especially if the patient has waited several days before seeking help. At operation, under direct vision, the offending foreign body can be removed.

A little over a year ago Dr. Harvey Morrison, Roentgenologist, told me that Dr. Frederick P. Drew of Dedham, Massachusetts, had

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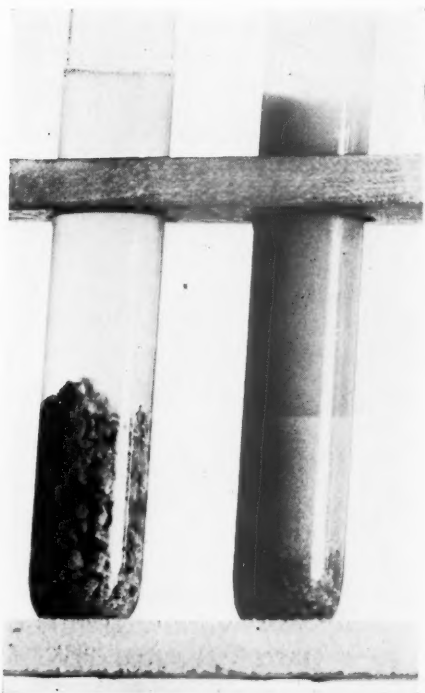


Fig. 1.—The digestive action of papain powder. Photograph taken one hour after one teaspoonful (grains 15) of papain powder had been added to the right-hand tube. Both tubes contained equal amounts of ground meat in broth. Both tubes were shaken thoroughly three times during the hour.

successfully dissolved impacted meat with a preparation called Caroid. Dr. Drew wrote me that he was impressed with the way Caroid digested or destroyed effete material in foul sloughing ulcers, leaving clean tissue ready to start granulating. For my purpose he suggested three or four more drams repeated as indicated. The idea appealed to me.

Investigation revealed that the chief constituent of Caroid is papain. Papain, papayatin or vegetable pepsin, comes from the juice of the fruit and leaves of *Carica papaya* L. (papaw tree). Papain contains enzymes similar to pepsin but they act in acid, neutral, or alkaline media. The usual grade of papain is said to digest about 35 times its weight of lean meat (Fig. 1). The best grade will render

soluble 200 to 300 times its weight of coagulated egg albumin in an alkaline media. The greyish-white powder, papain, is incompletely soluble in water and in glycerin.

Papain has long been used to aid digestion and gastric fermentation. At your druggist you will find papain combined with soda bicarbonate, with ginger, with pepsin, with bile salts and in many other combinations. It has been prescribed for all ages from infancy up. Other interesting uses of papain are to dissolve false membranes, to treat warts, to clear beverages, and to "tenderize" meats.

In this connection it is interesting to know that from time immemorial the fresh leaves of the papaya plant have been used by the Indians as a dressing for foul wounds and to wrap meat in to make it tender.

The following are summaries of consecutive cases in which this medicine was prescribed.

#### REPORT OF CASES

CASE 1. *B. E. B.; February 28, 1944.* A 69-year-old edentulous woman entered the Massachusetts Eye and Ear Infirmary because of dysphagia. For five days she had been unable to eat solids, since feeling a piece of meat stick while eating crackers and meat stew. She had been able to swallow fluids with difficulty. The patient had been treated for a constriction of the esophagus, resulting from typhoid fever. For the last ten years, she had been treated in the Bouginage Clinic at the Infirmary. At her last dilatation, on May 9, 1939, a non-opaque bougie, No. 37, was passed.

Examination on admission was not remarkable except for the x-ray findings. Dr. A. S. MacMillan reported "food just above the constriction in the lower end of the esophagus."

Papain, grains 15, and lactose, grains 45, were administered hourly as a powder with a minimum of fluids. One hour after the first dose the dysphagia was relieved and the patient could swallow normally.

X-ray study the following morning showed no foreign body or obstruction. The patient was discharged home to return for periodic bouginage. On March 9, 1944, a non-opaque, No. 36, bougie was passed. The patient reported that she had had no further difficulty, but wished to have some of the powder, "just in case something stuck again."



CASE 2. *K. T.*; *March 9, 1944.* A 66-year-old female with a complete upper denture entered the Massachusetts Eye and Ear Infirmary because of inability to swallow liquids or solids for three days. For the past week she had eaten little because of the death of her sister. Three days before, while eating beef and pork mixed, she developed complete inability to swallow. Regurgitation followed a few seconds after deglutition. The obstruction seemed to be at the lower end of the sternum. There was no pain suggestive of a bone.

Past history showed that she had had a nonmalignant obstruction of the lower esophagus for 16 years. During these years she had required periodic bouginage. In 1937, her esophagus became obstructed and a large amount of meat was removed by esophagoscopy under ether. Subsequently, the patient has been dilated with a mercury bougie about every three months.

Examination on the present admission showed an upper respiratory infection with mild bronchitis and laryngitis.

Caroid, grains 15, and lactose, grains 15, as a powder were ordered hourly. The patient could not retain any powder or liquid—her esophagus was too full.

The following morning, esophagoscopy under ether anesthesia revealed the esophagus full of fluid with a few particles of meat blocking the fibrosed, lower end of the esophagus. The stricture was dilated up to a No. 24 bougie.

The patient made a good convalescence with the aid of sulfadiazine. Dr. MacMillan's x-ray report on March 13 reads, "Barium passes through lower end of the esophagus. Patient maintains a fluid level to the episternal notch. Chest negative." On the 17th, she was discharged home to return to the Bouginage Clinic. She has done well since, returning every two months for the passage of a No. 36 mercury bougie. Her last visit was on October 25, 1944.

CASE 3. *M. H.*; *March 12, 1944.* A 75-year-old edentulous woman was admitted to the Newton Hospital at 5:30 p. m., because of inability to swallow liquids or solids. At noon, while eating beefsteak, turnip greens, and mashed potatoes, she felt something go down wrong, stick and thereafter she could get nothing up or down. Attempts to swallow fluid caused immediate retching. She had some cough and difficulty in breathing. She had had no previous difficulty in eating.

Examination of the hypopharynx failed to disclose any foreign body. The larynx was normal. A lateral x-ray film of the neck showed a mass in the upper esophagus, just below the level of the cricoid cartilage. No bone was evident.

One dram of caroid was dissolved in a glass of warm water. The patient was asked to sip, through a glass tube, and to hold the sips as long as possible, if she could not swallow them. She was told that she must take one glass of the mixture each hour. She was given morphine, grain 1/6, subcutaneously and scopolamine, grain 1/150. After two hours and two glasses, she vomited up meat fragments, turnip greens, mashed potatoes and caroid. Except for a burning sensation in her mouth, she had no complaints and could drink freely.

Fluoroscopy of the esophagus the next morning showed a normal esophagus.

CASE 4. M. R.; *March 19, 1944*. A 49-year-old former nurse, the wearer of a partial plate, inadvertently tried to swallow a large piece of steak one hour prior to admission to the Massachusetts Eye and Ear Infirmary. The meat lodged in her throat and thereafter nothing would go up or down. She had had no previous difficulty in swallowing.

Examination of the hypopharynx showed no foreign body although there was considerable saliva. A lateral x-ray film of the neck showed a mass in the upper esophagus just below the level of the cricoid.

The patient was given morphine, grain 1/4, atropine, grain 1/150; and one teaspoonful of caroid-sucrose mixture to a glass of water was administered in sips at the rate of one glass per hour. In an hour and fifteen minutes, she felt the caroid solution pass through, vomited and was thereafter able to swallow fluids with ease. She was discharged home the following morning symptom free.

CASE 5. J. C. M.; *April 3, 1944*. A 41-year-old male entered the Massachusetts Eye and Ear Infirmary because a piece of meat was lodged in his esophagus. Five hours previous to admission, while eating ham, he felt a piece stick low in his neck. This was not unusual as he had on 12 or 13 previous occasions had things "stuck in his throat" requiring hospitalization and operative removal. At three years of age, he swallowed lye and has had a narrow food passage-way ever since. On May 10, 1942 he had last entered the Infirmary. At that time, he had had ham "stuck in his throat" for six hours. One hour after morphine, grain 1/6, and atropine, grain 1/150, had been

given, I passed an esophagoscope under ether and removed a moderately large piece of meat impacted in a stricture. Convalescence was normal and Dr. MacMillan's fluoroscopic examination at discharge showed "constriction, upper end of esophagus at the level of the episternal notch to about a 34 French." Bougies No. 26 and 28 were passed in the Bouginage Clinic on May 28, 1942 and June 11, 1942.

Examination at the present admission was not remarkable save for considerable mucus in the hypopharynx. A lateral x-ray film of the neck was reported by Dr. MacMillan: "Meat, upper end of the esophagus."

Caroid and lactose were mixed in glycerin and a teaspoonful of the mixture prescribed hourly. One hour after a single dose of the caroid mixture, the patient swallowed his meat and could then take fluids without difficulty. He was discharged home the next day symptom free and referred to the Bouginage Clinic.

CASE 6. *E. B.*; May 15, 1944. An 83-year-old edentulous white woman was admitted to the Massachusetts Eye and Ear Infirmary because of inability to swallow even fluids for six days.

Her past history is instructive. At the age of four she drank oil of vitriol. Thereafter, unless she chewed her food carefully, it stuck. On January 6, 1910 Dr. H. P. Mosher operated under ether and found a stricture of the esophagus about the size of a lead pencil at the level of the clavicle. With mechanical dilators he stretched it up to the size of a No. 28 French bougie so that an esophagoscope could be passed. At the lower end of the esophagus another stricture was encountered, the size of a No. 20 French bougie. This lower stricture he could not dilate.

During the next few years bouginage was carried out at frequent intervals. Improvement was so marked that in 1916 when Dr. Mosher had the patient fluoroscoped with a No. 40 bougie in place he saw no abnormalities.

The patient passed a bougie herself up until 1920. For the next nine years she had no difficulty in swallowing. Then in 1930, she had increasing dysphagia. X-ray examination by Dr. MacMillan on October 14, 1930, showed, "two areas of constriction, one at the level of the episternal notch, the other just below the arch of the aorta. Lumen is about half normal size. No evidence of malignancy."

Bouginage was again started. She was discharged from the Massachusetts General Hospital medical service on November 8, 1930,

with a diagnosis of hypertensive heart disease, nephritis, and arteriosclerosis.

From 1930 through 1942 she visited the Boston City Hospital but returned to the Massachusetts General Hospital on June 30, 1943, because of ankle edema, dizziness, failing vision, occasional angiod pain and nocturia.

On November 1, 1943, she was admitted to the Massachusetts Eye and Ear Infirmary because of inability to swallow anything by mouth for five days. X-ray films showed food in the constriction in the lower end of the esophagus. Dehydration was corrected and although the medical consultant said she was a poor risk, under ether anesthesia, I passed a small esophagoscope, removed the obstructing food and dilated her stricture with a bougie. Convalescence was uneventful.

The present admission on May 15, 1944, again was because of inability to swallow even liquids for six days. There was no pain or discomfort suggestive of a bony foreign body. X-ray films failed to show a bone. In this dehydrated, old lady, with heart disease, conservative therapy was indicated. Intravenous 10% glucose and physiologic sodium chloride solution were given. One teaspoonful of caroid, lactose and glycerin mixture was administered in small portions for one hour. The patient could then swallow liquids. The following day she was able to swallow milk and was discharged home.

On May 25, 1944, she returned to the Infirmary saying that she had not swallowed well for ten days after her previous discharge. She was again given the caroid mixture as above and again in an hour could swallow. A No. 39 mercury bougie was passed the next day. This gave her the relief she sought. She was discharged improved to return in one month. On June 27, 1944, the No. 39 mercury bougie was again passed without difficulty. For the past month she said she had been eating satisfactorily at home.

CASE 7. *M. D.*; May 25, 1944. A 53-year-old white, edentulous female entered the Emergency Ward of the Massachusetts General Hospital complaining that a meat bone was lodged in her throat. While eating supper, four hours earlier, she swallowed a large fragment of a pork chop. Coughing failed to relieve a sensation of discomfort in the right side of the neck just below the thyroid cartilage. When her family physician tried unsuccessfully to remove the foreign body, the patient retched but could not vomit and was unable to swallow liquids.

Examination of the pharynx showed injection of the posterior wall. There was no foreign body visible in the hypopharynx. A lateral x-ray film of the neck failed to show any evidence of bone in the esophagus. There was evidence of a space-occupying object (presumably meat) just below the level of the cricoid in the upper esophagus.

Caroid-sucrose and glycerin mixture was given in sips for one hour. At the end of one and a half hours, the patient could swallow liquids without difficulty. She was discharged home the following day symptom free.

CASE 8. R. J. M.; *June 29, 1944.* A 38-year-old woman was admitted to the Massachusetts Eye and Ear Infirmary because of inability to swallow. Twenty-four hours previously, while eating liver, she felt a piece "stick" and was unable to swallow liquids or solids since. Her past history is irrelevant except that she had trouble swallowing at times "when she is nervous."

Local examination was not remarkable. X-ray films were interpreted by the house officer as showing a foreign body (presumably liver) in the upper third of the esophagus.

An intravenous injection of 1500 cc. of 5% glucose in physiologic sodium chloride solution was given. Morphine sulphate, grain 1/6, and atropine, grain 1/200, were given subcutaneously. One half to one dram of caroid solution (in glycerin), just enough to stay down, was administered every 15 minutes. After a half hour of medication the patient passed the foreign body and swallowed normally.

Fluoroscopy on June 30, 1944, showed a web at the level of the episternal notch causing considerable obstruction and a small traction pouch in the middle third of the esophagus. Non-opaque bougies, No. 28 and No. 30, were passed without staining. The patient was discharged improved and advised to return for further bouginage.

CASE 9. S. T.; *July 3, 1944.* A 48-year-old woman with a stricture of the lower end of the esophagus was admitted to the Massachusetts Eye and Ear Infirmary because of liver "stuck" in her esophagus. Two and a half days previously, while eating liver, she felt a piece "stick" at the level of the xiphoid. Since then, she had been unable to swallow liquids.

The past history reveals that for about eight years she had had difficulty in swallowing. Seven years ago at another hospital during an exploratory laparotomy the stomach was opened and the esophageal cardia dilated with the index finger. On February 16, 1938, the

patient was admitted to the Massachusetts Eye and Ear Infirmary because of inability to swallow solids. X-ray films suggested terminal fibrosis of the esophagus. Esophagoscopy demonstrated a fibrous band, 15 inches from the upper incisor teeth. Periodic bouginage has been carried out since; the lumen increasing from No. 34 to No. 39. The last bouginage was on June 22, 1944.

Examination on admission was not remarkable. The patient was given caroid solution,  $\frac{1}{2}$  dram every half hour. The house officer records "after about one hour of caroid solution down esophagus—the liver passed and patient is now swallowing liquids freely." She was discharged home that afternoon swallowing satisfactorily. She returned to the Bouginage Clinic on August 17, 1944, having had no further difficulty in eating and a No. 39 mercury bougie was again passed.

CASE 10. W. E. B.; August 17, 1944. A 65-year-old, edentulous man entered the Massachusetts Eye and Ear Infirmary because of inability to swallow solids for two days following a meal of chicken fricassee. Since then a slight amount of liquid had been swallowed but solids would not pass.

His past history revealed that about 11 years ago he began to notice difficulty at times in swallowing solids. Usually a glass of water would force the object down. Four years ago, on June 24, 1940, he was admitted to the Infirmary because of complete esophageal obstruction of five days' duration which followed the swallowing of a piece of raw codfish. X-ray films showed a large foreign body in the lower end of the esophagus above an area of fibrosis. Under ether anesthesia, an esophagoscopy was done and a large piece of fish was removed from above a stricture at the lower end of the esophagus. The patient was thereafter treated in the Bouginage Clinic. Regular passage of a No. 46 mercury bougie through the stricture gave him relief of symptoms.

At the present admission, on August 17, 1944, an attempt was made to pass the No. 46 bougie in the Bouginage Clinic. The bougie would not pass. Fluoroscopy showed that "There is a non-opaque defect just above the stricture. This gives a cap effect to the barium column. Findings consistent with a large chunk of food resting just above the stricture. A small amount of barium did pass into the stomach."

On admission to the hospital at 4:30 p. m., he received a teaspoonful of caroid, lactose and glycerin. At the end of an hour, as there was no more caroid available, papain was substituted. Two

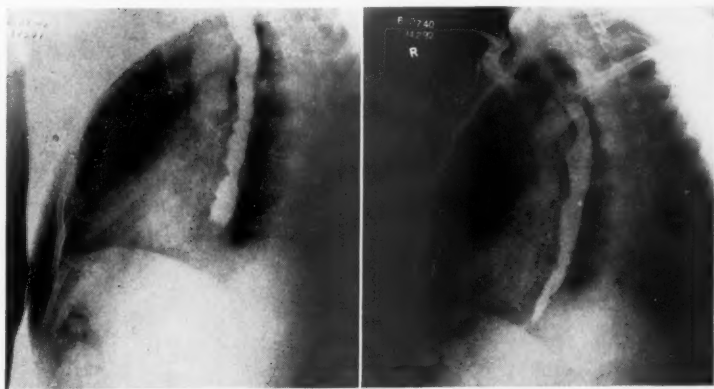


Fig. 2.—Roentgenogram of Case 10. Obstruction of the lower end of the esophagus is demonstrated by barium. An unusually large amount of barium was used in order to show on the film the hyperactive peristalsis of the esophagus that is best seen fluoroscopically.

Fig. 3.—Roentgenogram of Case 10. After removal of foreign body, there is no obstruction and barium passes through the esophagus, indented by a stricture in its lower third (at the site of obstruction seen in Fig. 2). The hyperactive peristalsis is no longer present; only the normal indentations of the heart, the great vessels and the bronchi are present.

doses were given an hour apart. An hour later, at 9:30 p. m., the patient could swallow everything satisfactorily. The next day he was discharged improved.

On October 25, 1944, he returned to the Bouginage Clinic doing well, but anxious for his regular dilatation with the No. 46 mercury bougie which passed easily.

**CASE 11.** *T. I. C.; September 19, 1944.* A 46-year-old male came into the Massachusetts Eye and Ear Infirmary Bouginage Clinic complaining of inability to swallow liquids or to vomit for 14 hours.

This patient was listed as missing for five days in the last World War. He was gassed during this time and has never felt quite the same. Since 1918 he has been treated off and on for cardiospasm. For the past year, No. 51 and No. 62 mercury bougies have been employed regularly and the patient has been improved by this treatment.



Last night, while eating roast pork, he felt a piece stick and has been unable to pass anything up or down since. Ordinarily when things stick he could vomit up the foreign body, but he was unable to do so this time.

Fluoroscopy, by Dr. MacMillan, showed complete obstruction of the lower end of the esophagus. The patient regurgitated the barium, but could not swallow water.

He was then given one teaspoonful of caroid, with a little sugar, in water. The patient drank half of this mixture and left the hospital. He returned one hour later, at 11:10 a. m., and took the other half of the mixture, so that a total of one teaspoonful of caroid was administered. At 11:15, he felt the meat slip through into his stomach. He was then able to swallow a glass of water with ease and was discharged improved.

CASE 12. F. M.; *September 29, 1944.* A 44-year-old woman came to my office choking following the eating of lamb stew. She had never had any difficulty in swallowing previously, but for one hour she had been unable to swallow liquids or to keep them down. This condition followed immediately after a piece of lamb lodged in her throat. She wore false teeth, and before she knew it had swallowed too large a piece of meat. There was no sensation of sharp pain or discomfort suggestive of a bone. She was salivating profusely which made her choke and cough. She felt as though something were pressing on her airway.

Examination of her throat failed to show any foreign body. There was a large amount of saliva in each pyriform sinus. Both parotid glands were steadily squirting secretion. When the pyriform sinuses filled, mucus flowed over into the larynx and caused coughing. The patient was unable to swallow water which, too, overflowed into the larynx. My diagnosis was meat high in the esophagus. No x-ray films were taken.

Caroid, one teaspoonful in  $\frac{1}{4}$  glass of water, was administered in sips beginning at 6:15 p. m. The patient could barely retain sips which occasionally poured over into the larynx and caused coughing. In 30 minutes with no other treatment, she regurgitated a piece of lamb, 2 inches long and  $1\frac{1}{2}$  inches in diameter. She then swallowed normally.

The patient was seen one month later and reported that she had had no further difficulty in swallowing.



Fig. 4.—Roentgenogram of Case 13. Lateral x-ray film of the neck taken to show soft tissue detail. A space-occupying mass, presumably meat, with an air bubble just above, can be seen in the upper end of the esophagus. Note the absence of teeth.

CASE 13. A. B.; October 8, 1944. A 63-year-old, white, edentulous woman was admitted to the Massachusetts Eye and Ear Infirmary because of inability to swallow. Twenty-four hours previously, while eating steak, she felt a piece lodge in her throat. It seemed to be at the suprasternal notch. She had not been able "to keep anything down" when she tried to swallow liquids. Her past history revealed that while she has had difficulty in digesting certain types of food, she had never had anything "stick" before. She has had an acute rhinitis for the past week; on admission she had a fairly severe cough.

Examination showed no foreign body evident in the pharynx or the hypopharynx. The latter was filled with saliva.

Lateral x-ray films of the neck were reported by Dr. MacMillan to show, "Foreign body—meat—in the upper esophagus."

Caroid, lactose and glycerin mixture was prescribed, of which, the patient could take only sips. Half a teaspoonful was taken each hour for a total of four times. She then had a half teaspoonful every 15 minutes for eight doses. A whole teaspoonful was given and within 30 minutes she swallowed normally. This treatment took 7½ hours—a longer time than any other case, probably because she had a larger piece of meat impacted.

Fluoroscopy the next day showed a normal esophagus. The patient was discharged home swallowing normally.

CASE 14. *B. M.; October 25, 1944.* A 58-year-old woman with an upper plate entered the Massachusetts Eye and Ear Infirmary because of dysphagia of four hours' duration. This was the first time she had ever had a doctor of any kind. She had never had difficulty in swallowing except that on three previous occasions something had stuck in her esophagus, but each time a glass of water had forced the substance down. At 6:00 p. m., the evening of admission, while eating meat at dinner she suddenly noticed a full, blocked sensation in the region of the upper sternum. She was unable to "get anything up or down." Water and all that she took was promptly regurgitated. She had no sharp pain suggestive of a bony foreign body.

Local examination was not remarkable.

Fluoroscopy demonstrated that barium stopped at the level of the clavicle.

One cubic centimeter of 5% papain in 10% alcoholic solution was given every 15 minutes. A total of five doses were given. The first three doses were regurgitated fairly promptly. The fourth dose was retained. After the fifth dose the patient swallowed normally.

X-ray study the following morning showed a normal esophagus. She was thereupon discharged home as well.

CASE 15. *E. B.; October 28, 1944.* A 50-year-old man was admitted to the Massachusetts Eye and Ear Infirmary because of inability to swallow food. Twenty-four hours previously, while eating steak, he felt a large piece, devoid of bone, slide down and stick in his esophagus. Since then he has been unable to get food up or down.

His past history reveals that in childhood he swallowed a caustic, which he thinks was lye. He has since always had difficulty in eating large bits of food. Two esophagoscopies at another hospital preceded his first admission to the Infirmary on March 23, 1936, when there was a piece of roast beef lodged in his throat for 24 hours. Under ether anesthesia, the meat was removed from its resting site in a stricture, 9½ inches from the upper teeth. The patient did not follow advice to attend the Bouginage Clinic.

On September 5, 1938, he again entered the Infirmary because a piece of ham had obstructed his esophagus for 24 hours. Under ether anesthesia, esophagoscopy, removal of the meat, and dilatation

of the stricture were done. Again, he did not return for further treatment.

On April 11, 1939, he again returned to the Infirmary because ham had obstructed his esophagus for 24 hours. Again, esophagoscopy, under ether, was necessary. However, he failed to attend the Bouginage Clinic after his discharge.

Examination at the present admission showed an edentulous mouth and a reddened pharynx; otherwise, the findings were normal. The diagnosis was steak in the upper esophagus.

Papain, dram  $\frac{1}{2}$  every half hour was ordered and an intravenous injection of 1500 cc. of physiologic sodium chloride solution with 5% glucose was given. After three doses in  $1\frac{1}{2}$  hours, the meat passed and the patient could swallow normally.

X-ray films on October 30, 1944, showed "constriction at the level of the arch of the aorta—lumen about 18 French." Hopefully and earnestly, he was again advised that he needed periodic bouginage.

CASE 16. *M. B.; November 23, 1944.* A 6-year-old girl entered the Massachusetts Eye and Ear Infirmary because of inability to swallow anything by mouth for 24 hours, following the eating of a meat (lamb) sandwich. Except for inability to swallow or vomit, she had no pain or discomfort.

Her past history revealed that two years ago she swallowed lye powder, mistaking it for Marshmallow Fluff. Her treatment at other hospitals failed to restore a good esophagus. On one occasion she was dilated up to a No. 20 bougie; but 11 months after swallowing the lye, the passage of a No. 15 bougie, under ether, was followed by mediastinitis and left-sided empyema. Penicillin and rib resection drainage obtained excellent results. For the past year she had had to subsist on a liquid and soft solid diet because of her very narrow esophagus.

Examination at the present admission was not remarkable. The diagnosis very evidently was meat in the esophageal stricture.

Papain solution, 1 cc. every 15 minutes, was the sole treatment. Sips of water were attempted after three doses of papain, but the water was promptly regurgitated. Four and a half hours after starting treatment, a full glass of water was easily swallowed and then a glass of milk was taken with enjoyment.

X-ray study the following day showed a stricture at the junction of the upper and mid-third of the esophagus. This stricture four

days later could be dilated under ether, only up to a No. 14 bougie. A No. 15 would not pass. Further dilatation is to be carried out in this case.

CASE 17. *L. S.; November 24, 1944.* A 49-year-old, edentulous, white woman came to the Massachusetts Eye and Ear Infirmary because of inability to swallow liquids or solids for the past four hours since eating the white meat of chicken. In infancy this patient had swallowed washing powder. All her life she has had to be careful to chew her food well. Twice previously she had been admitted to this hospital. On June 1, 1942, she was admitted because of "chicken" meat stuck in her throat. At esophagoscopy, under ether, I recovered not only chicken meat, but also half an almond nut. On February 1, 1943, esophagoscopy, under ether, was necessary to remove meat that had obstructed her esophagus for two days.

Examination at the present admission was not remarkable save for the lateral x-ray film of the neck. The report was "foreign body at the level of the episternal notch—no evidence of bone."

One teaspoonful of papain solution every 15 minutes was the sole medication. Before the third dose, 45 minutes after the first dose, the patient swallowed the foreign body and was able to drink a glass of water without difficulty.

The following day she was discharged home symptom free after fluoroscopy of the esophagus by Dr. MacMillan. This report read, "There is a waist-like narrowing of the esophagus at the level of the first dorsal vertebra—width about the size of a No. 36 French bougie."

#### COMMENT

This group of 17 consecutive patients with esophageal obstruction due to meat impaction, ranged in age from 6 to 83 years. The two youngest were 6 and 38 years of age and the two oldest were 75 and 83. Hence the majority of these patients were in the fifth, sixth or seventh decade of life.

The age of the group as a whole was shown by its dental equipment. Only two adults in addition to the six-year-old child had good teeth: each of these three had a strictured esophagus. Two other adults had teeth of their own: one had many teeth missing and the other had broken teeth and many infected roots. The remaining 12 patients had no teeth of their own. The upper plate worn for mastication was blamed by them as the cause of their mishap. The upper artificial denture takes away the ability to feel food between the

TABLE 1.—TABULAR SUMMARY OF CASES

CASE	AGE	SEX	TEETH	ESOPHAGUS STRICTURED	BOUGINAGE 'DILATATION	PREV. OP. F. B. REMOVAL	F. B.	DURATION	LOCATION	RESULT
1	69	F	Denture	Yes	Yes	0	Meat	5 Days	Low	Normal—1 Hr.
2	66	F	Denture	Yes	Yes	1	Meat	3 Days	Low	Operation Necessary
3	75	F	Denture	No	No	0	Steak	6 Hrs.	High	Vomited—Normal—2 Hrs.
4	49	F	Denture	No	No	0	Steak	2 Hrs.	High	Normal—1 1/4 Hrs.
5	41	M	Poor	Yes	Yes	12	Ham	5 Hrs.	High	Normal—1 Hr.
6	83	F	Denture	Yes	Yes	1	Meat	6 Days	High	Normal—1 Hr.
7	53	F	Denture	No	No	0	Pork	4 Hrs.	High	Normal—1 1/2 Hrs.
8	38	F	Poor	Yes	No	0	Liver	24 Hrs.	High	Normal—1 1/2 Hr.
9	48	F	Good	Yes	Yes	0	Liver	2 1/2 Days	Low	Normal—1 Hr.
10	65	M	Denture	Yes	Yes	1	Chicken	2 Days	Low	Normal—5 Hrs.
11	46	M	Good	Yes	Yes	0	Pork	14 Hrs.	Low	Normal—1 1/4 Hrs.
12	44	F	Denture	No	No	0	Lamb	1 Hr.	High	Vomited—Normal—1 1/2 Hr.
13	63	F	Denture	No	No	0	Steak	24 Hrs.	High	Normal—7 1/2 Hrs.
14	58	F	Denture	No	No	0	Meat	4 Hrs.	High	Normal—1 1/4 Hrs.
15	50	M	Denture	Yes	No	0	Steak	24 Hrs.	High	Normal—1 1/4 Hrs.
16	6	F	Good	Yes	Yes	0	Lamb	24 Hrs.	High	Normal—4 1/2 Hrs.
17	49	F	Denture	Yes	No	2	Chicken	4 Hrs.	High	Normal—3/4 Hr.

tongue and the hard palate. Consequently, an overly large bolus of the food may pass back to the soft palate and be promptly swallowed; sooner, indeed, than the victim intends. In this small series of cases the chief etiologic factor in obstruction of the esophagus by meat was the artificial upper denture.

It should be noted here that alcoholic beverages had not been taken by any person in the group.

The sex distribution shows that there were only four males. The preponderance of females, three to one, might seem to indicate that the process of filling the inner woman is more carefree than that of filling the inner man.

Six of the 17 persons in the group studied had a normal esophagus. The other 11 had a narrowing or constriction of some portion of the esophagus. The cause of the narrowing varied from webs to lye strictures. Indeed, to maintain an adequate lumen for food, eight patients required periodic dilatation by esophageal bougies. Most of these patients had been accustomed for years to chew their food thoroughly so that it would go down readily. Nevertheless, previous attacks of complete esophageal obstruction caused by the ingestion of a foreign body had occurred in six of these individuals. Three of them had had one previous operative removal of meat. One patient had been operated on twice; one patient, five times previously; and lastly, one patient had had an operative removal of an obstructing foreign body no less than twelve times.

It is obvious that a small bolus of meat will block a narrow esophageal lumen and that a much larger bolus will be required to obstruct a normal sized esophagus. The amount of digestion necessary to reduce the size of the foreign body so that it will slide through depends on the individual case.

The various types of meat said to have been ingested made no difference in the results obtained by the use of the proteolytic enzyme, papain. In four cases the records list only "meat"; the other patients had esophageal obstruction after eating either steak, ham, pork, liver, chicken or lamb.

The duration of stay of the foreign body also made no difference in the results as far as could be noted. The shortest duration was one hour and the longest six days. Eight patients had their esophageal obstruction from one to 14 hours. Four more endured for 24 hours; and five individuals stoically waited two or more days, unable to eat or drink, before coming to the hospital for help.



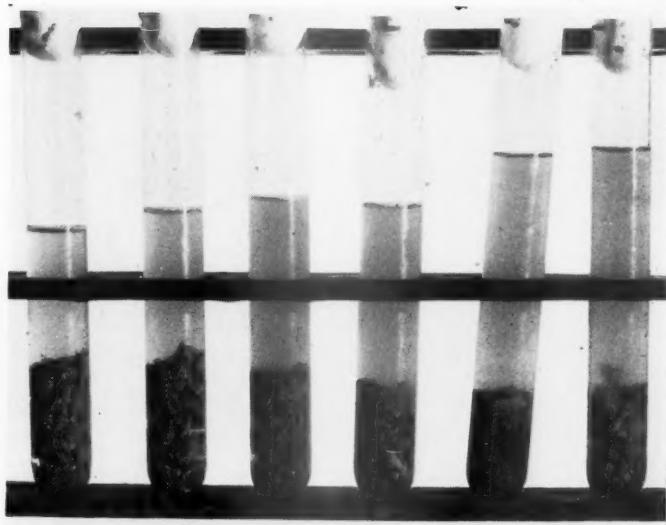


Fig. 5.—The proteolytic action of 5 per cent papain solution. All test tubes contained an equal amount of ground meat and broth one and one half hours before the photograph was taken. The first two tubes on the left were untreated. One cc. of 5 per cent papain solution was placed in the third tube, 2 cc. in the next, 3 cc. in the next, and 4 cc. in the last tube. All tubes were shaken four times. Notice the digestion of the meat particles.

At admission, examination of the hypopharynx with the laryngeal mirror failed to disclose the foreign body in any case. But when the foreign body was in the upper end of the esophagus, mirror examination did show saliva filling each pyriform sinus. Often, the secretion could be seen to overflow into the larynx.

In order to confirm the diagnosis, to determine the exact location of the foreign body, and especially to rule out the presence of bone, roentgen study was the next procedure. The lateral x-ray film of the neck was particularly valuable (Fig. 4). Most foreign bodies lodge in the upper end of the esophagus. In this series of cases, 12 of the 17 foreign bodies were located high in the esophagus. The five patients who had esophageal obstruction in the lower end of the esophagus all had constrictions in this location. All required periodic bouginage dilatation of their narrowed esophageal lumen. Fluoroscopy with, and sometimes without, barium demonstrated a foreign

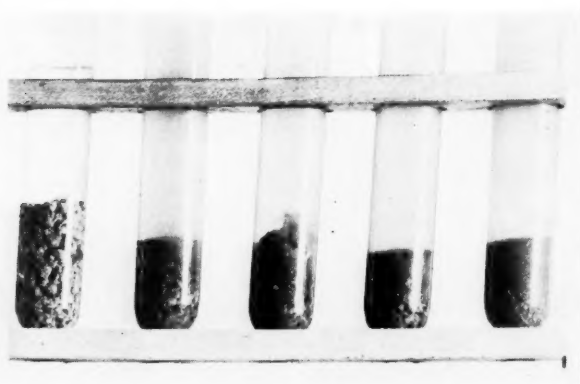


Fig. 6.—The proteolytic action of 5 per cent papain solution. All test tubes contained an equal amount of ground meat and broth one and one-half hours before the photograph was taken. The first tube on the left was untreated. Four cc., 8 cc., 12 cc. and 16 cc. of 5 per cent papain solution were added respectively to the remaining tubes. The proteolytic action is more marked as the amount of papain is increased.

body in the lower portion of the esophagus (Fig. 2). After fluoroscopic examination a patient with a low obstruction can often regurgitate the barium. Of course, the roentgenologist used as little barium as possible. The presence of barium did not seem to influence the speed of action of the digestive ferment.

When I first started to use caroid, I expected it to work best when meat was impacted low down. If the patient could regurgitate the contents of his esophagus above the impacted meat, there was adequate space for the proteolytic enzyme to work in a warm, active area. I did not expect success with the patient who had meat lodged high in the esophagus; such patients, I knew, were unable to swallow and keep down any appreciable amount of fluid. I thought it unlikely that they could retain sufficient proteolytic enzyme to be effective.

The method of administering the proteolytic enzyme thus varied as experience taught. The treatment used has been detailed for each case. At first the Residents at the Infirmary and I thought that caroid powder produced the best results. We gave it in various ways. For example, in high esophageal obstruction a teaspoonful of caroid powder dissolved in a glass of water was given with the advice to take

only sips and to hold each sip as long as possible. The patient was advised that one glass per hour would be given until the foreign body passed. Next, we tried using glycerin as a media. Also lactose was added to improve the taste. Finally, with the aid of the hospital pharmacist, we settled on a 5% solution of papain. This was dissolved in a 10% alcoholic vehicle. Thus we had a stock solution which would keep for a good many weeks. We found that as little as 1 cc. of this 5% papain solution administered every 15 minutes would yield good results. One cubic centimeter could be retained by a patient unable to swallow. When a teaspoonful could be taken, the meat digested more speedily.

This can be demonstrated in a test tube (Figs. 5 and 6). Ground meat in broth, obtained from the bacteriological laboratory, was shaken with varying amounts of a 5% papain solution. When photographed at the end of an hour and a half the action of the digestive ferment was clearly shown. All of the test tubes were filled with ground meat to the level shown in the left-hand test tube. In both pictures the left-hand test tubes were untreated. The larger the amount of papain solution, the greater was the digestive action in the same length of time.

In the series of 17 patients, three were given morphine and atropine. This proved to be of no advantage. The other 14 patients had no medication of any sort other than the 5% papain solution. This was done to be certain that the results were due solely to the digestive ferment.

The results of this therapy were gratifying. The first patient swallowed normally at the end of an hour after a single dose of 15 grains of papain. The second patient, like the first, had meat low in the esophagus, but she refused to persist in trying to swallow sips of caroid solution, or to take any of the dry powder. Regurgitation was prompt and had been so for three days. We did not insist that she try further because at that time we ourselves were dubious as to the value of our medicine. Perhaps if the fluid in her esophagus had been removed by a stomach tube, the caroid solution could have been retained. The next day her esophageal obstruction was relieved by operative removal of the meat. This second case is the only one in which we failed to succeed with the proteolytic enzyme. All of the other patients obtained prompt relief of symptoms. Esophageal obstruction was relieved within an hour and a half in 12 patients. Two patients required only a half hour; one, three-quarters of an hour; four, one hour; three, one and one quarter hours; two, one and one half hours. The longest time taken was seven and a half hours. The

length of time taken obviously depended on the size of the meat bolus and the size of the esophageal lumen in which the meat was impacted.

Two patients vomited the foreign body; the rest all swallowed the obstructing meat.

There were no untoward reactions and no complications developed.

After passing the foreign body, the patients could swallow liquids and solids as well as they had prior to the mishap. Fluoroscopy demonstrated the absence of obstruction and the lack of damage to the esophagus.

#### CONCLUSIONS

A series of 17 consecutive patients with esophageal obstruction due to meat impaction were treated by the oral ingestion of a proteolytic enzyme, papain.

Sixteen of these patients were promptly relieved of their obstruction.

The other patient, unable to retain the medicine, required operative removal of the foreign body.

The operative removal of meat causing esophageal obstruction will seldom be necessary if the patient is given orally the proteolytic enzyme, papain.

403 COMMONWEALTH AVENUE.

XXIX

MANAGEMENT OF CHRONIC MIDDLE EAR  
SUPPURATION WITH FISTULA

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The success of chemotherapy in various branches of medicine has encouraged the otologist to try many new drugs, especially the sulfonamides, in an attempt to avoid surgical procedures.

Recent reports have shown that the administration of the sulfonamides reduces acute surgical mastoiditis to some extent, although it is not altogether controlled.

In chronic diseases of the ear local application of the sulfonamides was preferred, and recently such authors as Lawson and Fenton<sup>1, 2</sup> have even advised its use in complicated cases. Authors reporting the use of a sulfonamide stressed the fact that all patients recovered.

Desirable as it is to avoid surgery in middle ear infections, it seems that some chronic changes of the mucosa and the structures of the pars petrosa do not respond to any conservative treatment.

Intracranial complications have occurred in spite of local conservative procedures. In such cases introduction of sulfonamides was insufficient to effect a cure due to their inability to reach the diseased mucous membrane and bone. For instance, a very small perforation in Shrapnell's membrane will not permit instillation of the drug into the diseased attic and antrum; cholesteatomata and debris covering the matrix may prevent the drug from reaching the diseased mucosa and bone.

In connection with chemotherapy, we should like to call attention to the treatment of chronic otitis complicated by a fistula and discuss the treatment of this complication as it is practiced at the Illinois Eye and Ear Infirmary.

In the fistula symptom test the vestibular reaction is characterized by a nystagmus of short duration, vertigo and occasionally past-pointing.

A positive symptom test may also occur without the presence of a fistula in the labyrinthine wall. This has often been found in acute secretory catarrh, where either an exudate or a mucous plug presses against the round window to disturb the relation in the two fenestra. Likewise, this has also been observed in cases of forceful catheterization of the eustachian tube.

In some cases an edema of the annular stapedial ligament can be the cause of an abnormal swinging fluctuation in the vestibule and may produce a positive fistula test on compression of air in the external auditory canal.

Ruttin<sup>3</sup> reported two cases with a positive fistula symptom test: the positive reaction was produced by the application of silver nitrate solution to reduce granulations in the operative cavity. The test was negative on pressure and became positive only on application of the drug.

A compression nystagmus or a positive fistula symptom test without a fistula in the labyrinth was described by Hennebert<sup>4</sup> in a number of cases of congenital syphilis. The positive reaction was explained by Lund<sup>5</sup> to be the result of a gumma in the oval window, causing excessive mobility of the stapes.

Another form of fistula test was reported by Mygind.<sup>6</sup> Where there are abundant granulations in the labyrinthine wall, the compression nystagmus may be absent, but pressure to the carotid artery produces a nystagmus to the opposite side of the diseased ear and a release of the pressure induces a reverse eye movement.

A positive fistula symptom test is not always the sign of a perfectly functioning labyrinth. In extended fistulas of the labyrinthine wall, filled with massive granulations, the mechanical pressure may produce a slow nystagmus although the labyrinth itself does not respond to caloric or rotatory stimulation. The slow eye movement merely indicates that the labyrinth has retained some functional irritability. Such findings are seen in chronic middle ear tuberculosis and occasionally in subacute protracted mastoiditis.

One should always remember that the clinical demonstration of a fistula does not necessarily require verification at the labyrinthine wall. The piercing channel of all three layers in the bony capsule may be of microscopic size and not visible during surgery.

The reverse findings are also true: a large fistula at the bony wall may not produce any clinical symptoms. Here it is assumed that either the fistula did not reach the perilabyrinthine space or scars were established to form a protective barrier before the labyrinthine lumen.

In the last three years ten patients suffering from chronic ear suppurations with circumscribed labyrinthitis were operated on at the Illinois Eye and Ear Infirmary. After analysis of the case histories, we tabulated the findings, according to the recommendation of White,<sup>7</sup> and obtained the following data:

*Race:* All white.

*Age:* The youngest patient was 13 years; the oldest 64 years.

*Sex:* 7 men; 3 women.

*Side of Suppuration:* The right side was involved 6 times and the left 4 times.

*Duration of discharge:* It varied from 1 to 24 years.

*Cause:* Twice scarlet fever was given as a cause; once measles; once tuberculosis; and once suppuration followed a "flu infection." In five cases the cause was unknown.

*Previous surgery upon the ear:* In one case a polypectomy had been performed.

*Nasal examination:* The examination was negative in 6 patients; the other 4 patients had septal deviations.

*Discharge:* The discharge was purulent and foul in 5 patients; in 7 it was combined with cholesteatoma.

*Acute exacerbation:* This occurred in 5 patients.

*Perforation:* In 8 patients the drum perforation was marginal and situated in the attic. One patient showed a total drum destruction, and the tuberculous patient exhibited a large central perforation.

*Symptoms:* All patients complained of dizziness and impaired hearing. The acoustic test showed a decrease to zero, or ad concham for whispered voice in 6 patients. Nine exhibited the positive fistula symptom test in varying degrees. A hyper-irritability of the affected labyrinth was found in 3 patients.

*X-ray examination:* Positive signs of bony absorption and rarefied areas characteristic of cholesteatoma were demonstrated. In the tuberculous patient cellular structure was revealed in the mastoid.



*Surgery:* A radical operation was performed on all 10 patients; in 2 the endaural approach was employed. Eight of the operations were performed under general and 2 under local anesthesia.

*Fistulas:* A fistula was found at the horizontal canal in only 2 patients.

*Plastic:* In 5 patients a one-flap plastic operation was employed. In the two endaural operations the flap fell out. One operation was performed according to the technique of Panse.

*Postoperative:* In 4 patients the middle ear cavities were dry 6 to 10 weeks after surgery. No records were obtainable for the others.

*Complications:* One patient was admitted with a diffuse labyrinthitis. In none of the patients were there postsurgical intracranial complications.

*Hospitalization:* The time spent in the hospital was from 9 days to 3 months.

*Postoperative Test:* The fistula symptom test was negative in 8 to 14 days after surgery. In one patient the symptom could be produced for 4 weeks after surgery.

In recording these cases we found that the symptoms of chronic ear suppuration, with or without a clinically positive fistula symptom test, varied according to the site of the fistula in the labyrinthine wall. The extent of the destruction in the middle ear, particularly at the tegmen tympani et antri, and the progressing necrosis of the bone in the area of the posterior fossa were the source of headaches and nausea.

Sudden head movements caused dizziness of short duration. An intense vertigo was rarely noted.

Past-pointing and falling reactions were only observed in patients with a very distinct fistula of longer duration. As a rule the eye movements were not persistent and included only a few rotatory motions.

In reviewing pathological sections from the collection of the Illinois Eye and Ear Infirmary, we found that correlative to the clinical symptoms the cholesteatoma prevailed in chronic ear suppurations complicated by erosions of the labyrinthine wall. The preference for the horizontal canal is due to the anatomic structure of the middle ear. In the narrow passage from the epitympanum to the antrum

the prominent horizontal canal is the point most exposed to pathological changes in this area.

Another deleterious factor lies in the microscopic outlets of the middle ear cavity which are situated near and posterior to the niche of the oval window. Here pus and cholesteatomatous debris favor an earlier erosion of the ampullar end of the horizontal canal.

Also of importance seems to be the fact that the ingrowth of the cutis from the external canal into the middle ear starts at the point where the skin is most vascularized. This area lies in the posterior upper angle of the external canal next to the recessus epitympanicus. The erosion and destruction of the horizontal canal was, of course, greater when there were large cholesteatomas of the antrum and of the mastoid process. The consumption of the bony capsule was accomplished mainly through the proliferation of osteoclasts. Though the subepithelial matrix itself exhibited only few inflammatory changes, the absorption of the bone appeared very predominant. (Fig. 1).

At the points where the cholesteatomatous matrix was small and nearly avascular, the underlying bony activity was more at a standstill. The structure of the matrix and its vascular state seemed to be responsible for the activity at the bone. (Fig. 2).

In other sections showing chronic suppuration without cholesteatoma, but with granulations and polypoid degeneration of the mucosa, one could also observe the destruction toward the labyrinthine wall. This was brought about either by perivascular absorption of the bony capsule or by direct osteoclastic consumption forming typical indentations at the bone (Figs. 3 & 4).

The inflammatory reaction of the perilymphatic and endolymphatic fluid varied according to the extent of the bony destruction. It appeared localized near the fistula and there was little, if any, change in the contents towards the nonampullated end of the canal.

Once the diagnosis of a fistula in a chronic suppurative ear was made, a radical operation was indicated. This indication, of course, could not be definite as long as the intracranial signs were absent. It appeared to be relevant only in regard to the time of surgery.

As a preoperative measure a minimum hospitalization of two to three weeks was recommended. At this time absolute bed rest was ordered to quiet the acute exacerbation, so as to reduce the danger of inflammatory propagation into the labyrinthine lumen and to pre-

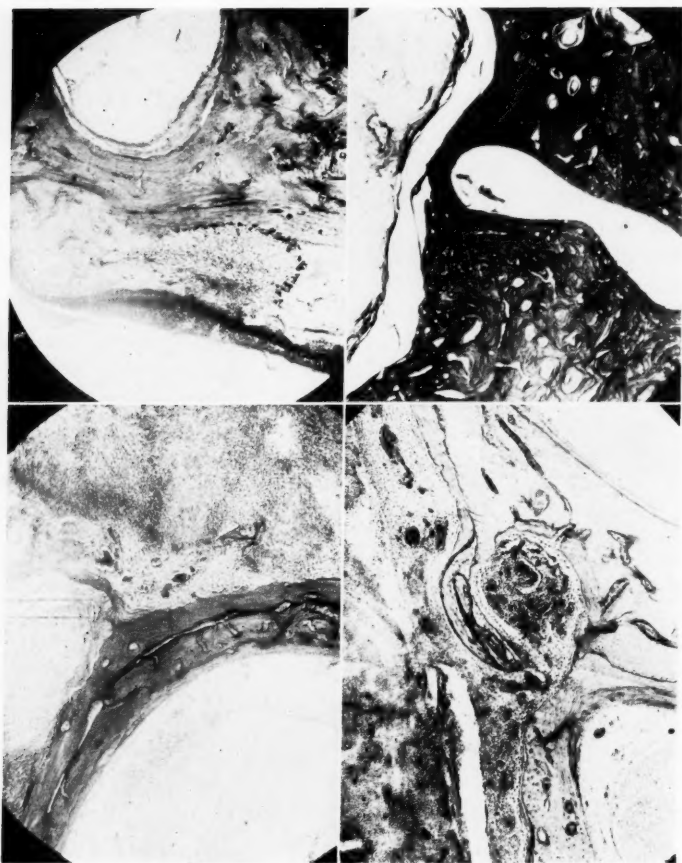


Fig. 1.—Chronic middle ear suppuration with cholesteatoma. Progressive osteoclastic erosion of the periosteal and enchondral labyrinthine bone. Inflammatory infiltration of cholesteatomatous matrix.

Fig. 2.—Cholesteatomatous matrix over the prominence of the horizontal canal without recent inflammatory reaction.

Fig. 3.—Chronic middle ear suppuration without cholesteatoma. Sequestration of the labyrinthine capsule through osteoclasts with typical indentation of the bone.

Fig. 4.—Chronic middle ear suppuration with granulations. Bone destruction partly accomplished through perivascular absorption.

vent some of the established but unconsolidated adhesions from breaking loose. The patients were also ordered to avoid quick movements of the head and to lie in the position giving minimum irritation, which was generally on the side of the direction of the slow component.

Manipulations in the middle ear, such as syringing, the use of drops, or attempts to remove granulations or polyps, were strictly avoided. Repeated daily tests for the fistula symptom were eliminated as being absolutely dangerous. The usual labyrinthine tests such as turning and calorization were restricted in patients with preserved hearing. For three days before surgery one-half of the usual dose of sulfathiazole was administered.

The choice of approach, whether classical with postauricular incision, or endaural, was a matter of personal experience and technique. It was essential that all diseased tissue, as far as anatomical conditions would permit, be removed. Typical and large radical cavities resulted.

As to the modification of the radical operation, the status of the middle ear only was considered. The presence of the positive fistula test and the findings at the horizontal canal did not require special attention. In all cases the area of the horizontal canal was left undisturbed. Reminders of the cholesteatomatous matrix in this region were not removed as this procedure was considered dangerous because it could spread the infection toward the labyrinthine lumen. When the interior of the cavity was completely cleaned and all cholesteatoma and granulations removed, much attention was given to the plastic flap-operation.

In contrast to the classical method, the flap should not cover the area around the horizontal canal. The purpose of this procedure is, in the main, to avoid retention under the plastic flap, although epithelization may be retarded. The restoration of the lost bone and the scarification of the granulations in this region appeared more accelerated. A one-flap method was employed: resection of the inner and upper corner of the external canal by an incision with a blunt end knife, beginning inwards from the upper meatal angle through the cartilaginous canal outwards. Two vertical incisions freed the flap which was rolled into the mastoid cavity.

Before suturing, the flap was thinned out by removal of excess connective tissue and by excision of the adherent cartilage in order to obtain a more flexible annex and to avoid postoperative perichondrial infection.

In patients operated on by the endaural method, the removal of a triangular piece from the external canal at the beginning of the operation made the flap unessential.

The operation having been completed, one gram of sulfathiazole powder was blown into the cavity and an iodoform pack loosely inserted through the external auditory canal and into the mastoid cavity.

If the sigmoid sinus or the dura mater was not uncovered the retro-auricular wound was sutured and permitted to heal by first intention.

For the next two postoperative days full doses of a sulfonamide were administered internally and the dose gradually decreased until the sixth postoperative day when it was discontinued.

Following the operation patients were watched for elevation of temperature, nystagmus, pulse rate, and wound infection. In the event of a complication the dressing was removed and the wound inspected; the sutures were removed and the packing omitted. In smooth, uncomplicated postoperative courses, the first dressing was changed on the sixth day and every other day thereafter. Packings were inserted into the middle ear cavity and any excess granulations were touched with a five per cent solution of silver nitrate. The mastoid cavity was powdered alternately with a microcrystalline sulfonamide and boric acid until epithelization had taken place.

#### SUMMARY

Ten cases of chronic middle ear suppuration complicated by a fistula are reported.

Topical or internal use of a sulfonamide in chronic middle ear suppurations with granulations and cholesteatoma appears to have value only pre- or post-operatively.

In the presence of a positive fistula symptom test a radical mastoidectomy is the operation of choice. Instrumental manipulations in the labyrinthine area are to be avoided and the located fistula left untouched.

To prevent retentions and to obtain smooth healing a one-flap plastic operation is recommended.

25 EAST WASHINGTON STREET.

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### XXX

## PREVENTION OF DEAFNESS IN CHILDREN

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Last year the physicians testing school children in Los Angeles found 3,734 children with defective hearing, which is 1.4 per cent of all Los Angeles school children. The United States Children's Bureau states that 2 per cent, at a minimum, of all school children are hard of hearing. The California State Department of Health reports 31 towns tested 74,000 children and found approximately 1,600 children deficient in hearing.

Because of these facts, I think it is necessary for us to give considerable attention to the prevention of deafness in children. It has been stated by Coates<sup>1</sup> and others that the most common types of middle ear deafness seen in adult life have their origin in childhood. In order for us to understand the prevention of deafness, it is best for us first to review the causes of deafness.

The primary causes producing deafness in childhood may be divided into three main classes:

1. Pathological changes occurring in the middle ear.
2. Pathological changes occurring in the eustachian tube.
3. Pathological changes occurring about the tubal orifice.

*Pathological Changes of the Middle Ear.* Changes in the tympanic membrane may include marked thickening or perforations. Fibrous thickening or adhesions of any part of the middle ear produce marked retraction of the drum head. Perforations may occur in any part of the drum and result in diminished vibratory transmission.

Changes occurring along the ossicular chain include granulations, necrosis, and disarticulation. Granulations may extend to either the promontory or drum membrane, or may be on or between the ossicles. Necrosis of the ossicles may result from chronic disease or

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from acute virulent infections. Disarticulation of the ossicular chain may result from concussion or other severe trauma. Occasionally the incus may be dislodged during myringotomy or simple mastoidectomy.

Edema of the mucosa of the middle ear may be either inflammatory or allergic in origin. If the edema is inflammatory, the tympanic cavity may become partially or completely filled with fluid. The acute inflammatory changes pass into the subacute or chronic form, or the fluid drains out or is absorbed and the membrane returns to its normal state.

In allergic edema the process is much the same as there is a swelling and congestion of the membrane without any infecting organism being present.

Repeated acute infections eventually lead to permanent pathological changes in the mucous membrane of the middle ear. These changes vary in degree of hyperplasia as it is more marked in chronic infections than in allergic conditions.

*Pathological Changes in the Eustachian Tube.* The tympanic cavity and the eustachian tube are lined with mucous membrane continuous with that of the nasopharynx. The eustachian tube therefore shares the inflammatory processes of the nose and throat. Its mucous membrane is different from that of the middle ear in that the racemose glands are present, and there is a large amount of lymphoid tissue near the pharyngeal orifice. It is possible for these glands to swell and remain swollen several weeks or months after an acute inflammatory process has subsided, thus causing partial or complete obstruction of the eustachian tube.

The allergic manifestations involving the eustachian tube are also associated with those of the nose and the nasopharynx. The same changes which take place in the nose and throat take place in the eustachian tube. After this process has continued for some period of time there may be polyp formations within the eustachian tube. There may be alterations in the racemose glands, the blood vessels, and even the fibrous tissue stroma.

Hypertrophy of the membrane results in narrowing of the tubal lumen and may result in complete closure of the tube. Strictures are occasionally encountered as the result of granulations within the tube.

*Pathological Changes in the Tubal Orifice.* Large adenoids or lymphoid nodules near the orifice of the eustachian tube interfere with

normal ventilation of the middle ear. A hypertrophied pharyngeal tonsil or adenoid is by far the most important predisposing cause of middle ear catarrh and early deafness in childhood. These growths press laterally on the orifice of the tube or they may completely cover the opening. The important relation of adenoids to tympanic disease is clearly seen as most all children suffering from adenoids will show some pathological condition in one or both ears. Children with large adenoid growths rarely pass through a severe exanthematous attack without aural complications.

The size of the adenoid is not so important as its location. A small adenoid which is in close proximity to the eustachian tube exercises a great deal more influence than a large adenoid which hangs free from the vault of the pharynx. We must consider tonsils and adenoids in relation to the amount of inflammatory reaction they exercise on the region of the eustachian tube. The eustachian tube of a child as a rule is well open, but it takes little inflammatory reaction to close it up; and moreover, on account of its patency, there is a susceptibility to infection of the middle ear from any infection of the nasopharynx.

If one understands the physical conditions of the hearing mechanism and appreciates the fact that any interference with the proper action of the eustachian tube is bound to bring about an abnormal air pressure within the middle ear, he will recognize the fact that irritative organs which are constantly infected, such as tonsils and adenoids, are a constant menace to the child and that the ears are very apt to suffer before any other condition is noted.

The influence that tonsils play on the hearing mechanism may be brought about in one of two ways—either by their acting as an actual obstruction to the eustachian tube or else by their continually infecting the tube; and the small tonsil may be as great a menace as the large one, depending upon the amount of obstruction or the amount of infection present.

Other factors which may be considered predisposing causes of deafness in childhood are nasal abnormalities, particularly those which are associated with suppurative conditions which allow a continuous discharge of pus or mucus into the nasopharynx.

New growth in the naso-pharynx may act as an obstruction about the tubal orifice.

There may be considerable scarring about the orifice of the eustachian tube following surgery in the nasopharynx. This may

produce either partial or complete closure of the orifice of the tube or may result in an abnormally open or patent tube.

One of the greatest factors in the prevention of deafness is early diagnosis. Recent advances in present-day methods of group testing in schools and audiometric examinations, although still not too reliable, have done much to locate and diagnose early cases of deafness.

Our national, state and city health departments are active with definite programs designed for hearing conservation. It is time that we as otologists assist these programs by giving them our wholehearted cooperation, and by our early recognition and correction of the pathology which may lead to deafness.

65 NORTH MADISON STREET.

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XXXI

THE STENGER MALINGERING TEST MADE  
WITH THE AUDIOMETER

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The detection of malingerers of deafness and those who exaggerate their hearing loss has been one of the hard problems of otologists. When the war is over, we may expect to see a very large number of patients claiming a loss of hearing resulting from industrial causes or from war injuries. They will rightfully request an evaluation of their hearing loss and compensation for industrial or service-connected disability. Among them there will be some who are malingering, or at least exaggerating their hearing loss.

In these busy times the otologist must rely upon hearing tests done by a technician. Careful hearing tests are the first step in detection of malingering, and the average technician is not trained to detect these cases. Undoubtedly a great many cases are now going unrecognized.

The detection of malingerers of deafness is difficult. Although some otologists think it is very simple, it is interesting to note the variation in their reports on the same case. Frequently the findings of one observer are not verified by another, even though the same tests are used. Many of our tests depend upon the alertness of both doctor and patient. One malingerer may be so familiar with hearing tests that he escapes detection, whereas another may be easily discovered. Many tests seem to be positive one time but negative at another, even when made by the same examiner.

It is evident that there is a great need for otologists to have one malingering test upon which they can all agree. It must be very simple to perform, it must be absolutely reliable and foolproof, and it must be possible for any technician or physician to repeat and confirm the test. It is rather remarkable that otologists have not had a

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malingerer test as purely objective as the measurement of temperature or vision. Such a test would be a great advantage.]

[The Stenger test has been regarded by many otologists as the most reliable. As the method of conducting the malingering test proposed later in this paper is based upon the principles of that test, it is necessary to discuss it in some detail.]

[The Stenger test is based upon the physiological fact that a person with two normal ears will hear two identical pure tones vibrating at the same intensity at the same distance from each ear. If two identical forks are struck simultaneously with the same energy and held at equal distances from each ear, the tones will be heard equally in both ears. If one fork is moved closer than the other, the sound from that fork only will be heard. If the opposite fork is brought an equal distance nearer, the sound will be heard in both ears. Sound is lateralized in the ear that receives the greater intensity.]

[The Stenger test is done with tuning forks as follows: Two tuning forks of the same vibration (usually the 256 d.v. or 512 d.v.) are used. The patient is blindfolded. The good ear is tested by striking one fork and slowly bringing it toward the ear until the patient first hears it. The distance is measured from this point to his ear. Inasmuch as the malingeringer denied hearing the fork in the suspected ear, both forks are struck simultaneously; and while one fork is quickly placed near the suspected ear, the other fork is slowly brought toward the good ear. If he does hear the fork in his alleged deaf ear, he will not hear the other fork approaching the good ear until its intensity is greater than that heard in the alleged deaf ear. In other words, a definite discrepancy is noted in the distance at which the fork is heard in the good ear, with and without another identical fork vibrating in the suspected ear. This is a positive Stenger test and is excellent proof of malingering. It is particularly useful in that group of malingeringers which claims a total deafness in one ear and admits normal hearing in the other ear.]

[The many difficulties encountered when hearing tests are conducted with tuning forks are increased to such an extent in performing the Stenger test that many otologists who are convinced that this is fundamentally the best malingering test are unable to prove whether a suspected case is actually malingering or not. With the use of the audiometer, as later described, practically all of these difficulties are eliminated.]

When this subject was first presented at the meeting of the Western Section of the American Laryngological, Rhinological, and

Otological Society in Los Angeles on January 28, 1945, the equipment available to the author consisted of the Maico audiometer and an accessory malingering testing unit. This unit connects into either the air conduction or the bone conduction outlet, and it directs the tone to a headset with a right and a left ear receiver. This unit, or its equivalent is adequate and can be used with any audiometer. It should be noted, however, that the receivers on the headset furnished by this company have a threshold 30 to 40 decibels different from the receiver used routinely for audiometer testing. The simplest method to obviate this difficulty is to obtain one additional receiver of the same quality and threshold as that already supplied for audiometer testing. These two receivers can then be plugged into the accessory unit outlets for the right and the left ear.

The simplest equipment for conducting this test was found to consist of two ear receivers or earphones of the same calibration as the receiver used for the routine air conduction test on the audiometer. One receiver was connected into the air conduction outlet and the other was connected into the bone conduction outlet, thus eliminating the accessory malingering test unit. The simplicity of this equipment has so many advantages that testing with it is the method of choice with the older audiometers. However, the Maico Company in the latter part of 1944 changed their audiometer and with this new model it will be necessary to use a malingering test unit which will plug into either the air or the bone conduction outlet and directs the tone into the right and the left ear receiver as described in the previous paragraph.

With an audiometer and simple equipment as just described, any technician can easily be taught to do the test, which takes less than three minutes to complete. The technician who makes the routine audiometer tests should be instructed to make this Stenger test upon every patient who claims unilateral deafness.

It is recommended that the following technique be used in conducting the audiometer Stenger test:

1. Set the audiometer for one of the following frequencies: 256, 512, or 1024.
2. Test the deaf ear for air conduction as done routinely in performing a hearing test. The malingerer denies hearing the tone even when turned to the highest intensity.
3. Test the good ear with the other receiver which is connected into the bone conduction outlet. Turn the dial on the audiometer to

such a volume or intensity that this receiver can just be heard 20 inches from the ear. This requires about 50 decibels for a normal ear.

4. Blindfold the patient.

5. Again place the receiver connected into the air conduction outlet against the deaf ear, and while the tone is thus being directed into this ear, test the good ear again to determine the distance at which it is heard.

6. Record the results as a fraction, which will be determined as follows: His "normal" or threshold distance is expressed as the denominator of the fraction. This is the distance the receiver is heard from the good ear without the other receiver vibrating in his alleged deaf ear. For simplicity's sake this distance has arbitrarily been taken as 20 inches, but if the hearing in the good ear is impaired this distance may be reduced to six or ten inches. The numerator of the fraction is the distance that the receiver is heard from the good ear while the other vibrating receiver is held against the alleged deaf ear. If the tone is heard at 20 inches with and without the other receiver vibrating in the alleged ear, the audiometer Stenger test is recorded as 20/20. This indicates actual deafness in the alleged deaf ear, or in other words, he is not a malingerer. However, if he only hears the receiver at three inches from the good ear while the other receiver is held against the alleged deaf ear, it is recorded as 3/20 and means that he actually does hear in his alleged deaf ear, or in other words, he is malingering.

In trying out the above technique on patients, one very interesting observation was made. A small soundproof room is not as satisfactory as a large ordinary room. This was particularly noted in patients with a considerable loss of hearing in the good ear and for whom it was necessary to turn the audiometer to high intensity in order for them to hear 20 or even ten inches from the good ear. The walls of a small room seem to act as a sounding board when both receivers are vibrating at a high intensity.

#### CONCLUSIONS

The technique of conducting a Stenger malingering test on the audiometer, as just described, is very simply and quickly performed. It eliminates the difficulties encountered when this test is done with tuning forks. It is reliable and can be repeated by any technician or physician. The results of the test are expressed as a measurement in distance as an objective test.



The above test is particularly useful in those patients who claim a total loss of hearing in one ear and relatively normal hearing in the other ear. However, this test, with perhaps some modifications, can undoubtedly be used to detect patients who are exaggerating their hearing loss; and it may even be possible to detect how many decibels they are exaggerating. The technique for the detection of this type of case will require further careful study by the otologists.

U. S. NAVAL REPAIR BASE.

## EXTERNAL OTITIS IN THE SOUTH PACIFIC

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Fifteen months' experience in U. S. Naval Mobile and Base Hospitals in the Solomon and New Hebrides Islands, where external otitis was usually 50 per cent and sometimes as high as 70 per cent of our work, gave the author an opportunity for considerable clinical observation and, at one place, some laboratory investigation of this disease.

This observation led to two conclusions: First and most important, there are several types of external otitis, at least three of which are definitely distinguishable as this paper will attempt to describe, each requiring a different and more or less specific treatment; second, there are variations in the incidence and perhaps the types from island to island and from season to season. The laboratory studies, though never anywhere nearly complete, lent enough support to these conclusions to raise them at least somewhat above mere opinions.

The first of the three clinical types referred to is really entitled, I believe, to the name "fungus ear" which is generally and all too loosely applied to external and even some middle ear infections but which actually comprises only about one third of these cases. Its history, if obtainable, is distinctly different, being much slower and more insidious in development. Itching usually precedes other symptoms by days, weeks, or even months. The first discharge is serous, "weeping", and several periods of this may come and go during the itchy stage. Hearing is not affected unless the canal becomes obstructed with epithelial debris and discharge. Pain, which may become quite severe and increase rapidly, is the symptom most commonly bringing the patient to seek relief, and seldom subsides until proper treatment is given. It often starts after swimming or otherwise getting water in the ear, and too often is aggravated by irrigations given

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by a corpsman or some other inadequately trained or equipped sympathizer. The otomycotic type is particularly apt to have a history of many recurrences or relapses.

At this point I should like to interject an observation that the almost universal habit of turning the face up directly into the full force of a shower in bathing is as frequent a way of getting water in the external auditory canal as is swimming, especially in camps where showers are almost the sole method of bathing. Even if the tiny streams do not strike directly into the meatus, the concha tends to catch and divert them inward; whereas, if care is taken that the water falls only upon the top or back of the head, the "awning" of the auricle serves one of its natural purposes by deflecting it. Sufferers from repeated recurrences of otitis, at least, should be warned of this.

The findings in a fungus infection of the external ear are characterized by two outstanding features: exfoliation, and very superficial though perhaps quite violent inflammation. Exfoliation varies from mere scales to complete epidermal casts of the canal and may progress until complete epithelial denudation, granulating surfaces, or even exposure of the bony canal result. Perforation of the ear drum, which usually healed, but prolonged the course, occurred a number of times in advanced or severe cases. Mycelia and spores may be seen with the naked eye on some of the exfoliated masses. The desquamated debris may break down into a creamy, cheesy matter with a rancid to moldy odor, but the entire process always has a very superficial zone of activity and progresses comparatively slowly by direct extension. Very little swelling and not much tenderness are usually seen, and if present suggest the concurrent presence of the next type.

This second type comprises another good third of the cases seen. The history is of progressive and often rapidly increasing tenderness and swelling of the canal, often extending to the periauricular tissue, especially over the mastoid where a picture exactly resembling and frequently mistakenly diagnosed as acute mastoiditis may swiftly appear. Aching pain is considerable but is less sharp than in many otomycoses. There is generally scanty or no discharge. The hearing may become impaired rapidly if the canal swells shut. The findings are those typical of cellulitis anywhere in the body: acute, diffuse, active inflammation of the subcutaneous tissue with exquisite tenderness and marked swelling. The epithelium is intact, and localization and suppuration were not seen in any case. Some fever and leucocytosis may be present and the patient mildly toxic. In our

worst case, entering the hospital as "mastoiditis", facial paralysis had appeared the afternoon before. Only normal hearing after the occluded canal was opened with an infant's speculum, and clear x-ray films saved this patient from mastoidectomy, and the entire process, including the facial palsy, cleared completely in five days under our treatment for this type of external otitis. I believe this type is a true simple cellulitis caused by the pyogens usually responsible for such disease: staphylococci and streptococci.

The third type has a vague history of discharge, mild "soreness" and "fullness" in the ear. The canal is coated or filled with a soupy, pale greenish discharge having the characteristic acid, sour odor of *Pseudomonas aeruginosa*. "Sloppy" best describes the general appearance. When cleansed, the skin appears quite violently hyperemic, but is intact, and there is very little tenderness or reaction of the deeper tissues. This picture was seen alone in as many as one third of the cases at times, especially in the wet season, and remained as an obstinate residue in about another one third when one of the other types had subsided under treatment.

The descriptions above are of typical cases and were often seen as described. Mixed infections, especially those suggesting otomycosis complicated by secondary infection and cellulitis and the pyocyanus admixture just noted, were quite common and required recognition of the various factors and properly adjusted treatment to obtain the best and quickest result.

Some bacteriologic studies were undertaken, but shortage of specially trained technicians, special media, and reference works thwarted the pathologist's desire to carry them to a really conclusive end. They did, however, roughly confirm the clinical observations. A variety of fungi were found in smears and grown in cultures on such special media as were available in about one third of the cases studied serially. A few of these were identifiable as aspergilli and other fungi known to act as pathogens, but more were not. A fungus with very small coccoid hyphae, quite fragile and breaking up when smeared for staining to fill the field with bodies resembling micrococci, was found several times. Gram-positive cocci were found in about one third of the smears from the cellulitis cases, but were too often overgrown by *B. pyocyanus* on cultures; staphylococcus aureus and some streptococci were isolated in a few instances only. A gram-negative, motile bacillus was found alone and abundant in smears in one third of the cases, and in these *Pseudomonas aeruginosa* was grown in pure culture; and it was found on smears and grew profusely in cultures in another third of the cases of both types.

Our treatment was based on the concept of types described above; while a few cases were very stubborn, no case failed to clear up and the large majority responded so promptly, cleared so completely, and the incidence of recurrence, so far as we could tell, was so low that we were convinced, albeit perhaps too perfectly, that it was correct and sufficient. At least we did not search for nor try many new modes.

Thorough, painstaking, daily dry cleansing, with headmirror, speculum, fine cotton applicators and much perspiration by both physician and patient was a categorical imperative, particularly in the otomycoses, where a small plaque of exfoliated debris, especially hidden in the deepest recess, or "fornix", of the junction of the drum and the anterior canal wall repeatedly nullified any and all treatments at both other hands and our own, until removed. Cleansing alone will give symptomatic relief to ears with fungus infections but will not prevent immediate recurrence.

Packing the cleansed canal daily with cotton wicks saturated with cresatin, to be removed in two hours, was the standard treatment for the fungus infection. Excessive use of cresatin may burn some skin, so the time was often cut to one hour as soon as the disease was well under control, or even to mere painting for the last few days. Response was prompt and lasting in all correctly diagnosed cases; the average time required to dismiss a patient having a moderately severe infection was eight to ten days, all being observed for at least three days after being apparently "cured." These results were so satisfactory that other treatments, such as copper sulphate, tannic acid and sulfonamide powders, were not tried. Thymol-alcohol mixtures were disappointing in both immediate effect and prevention of relapse. The sulfonamides alone certainly had no effect whatsoever on this type. In some patients giving a history of chronic infection who had a scaly skin after all active signs of infection were cleared, daily filling of the canal with 2% salicylic acid in 95% alcohol for seven to ten days followed by applications of a bland ointment such as plain vaseline seemed worth while to prevent recurrences. The resumption of cerumen secretion seemed a favorable sign.

The cellulitis type responded excellently to similar daily packing with wicks thoroughly impregnated by rubbing in 10% sulfadiazine ointment and left in for 24 hours, dry heat, and sedatives for pain as required. Again, sulfonamide powders only seemed to cake and complicate the problem of cleansing. It might be expected that dry

powder would be ineffective when applied on intact skin. Systemic use of sulfonamides was not required, and penicillin was not plentiful enough to use experimentally on otherwise solvable problems.

*B. pyocyaneus* infections cleared with startling and deceptive rapidity, some of the "sloppiest" ears being perfectly dry, clean and healthy-appearing in 48 hours, upon packing for ten minutes with 5% sodium thiosulphate followed by 2% acetic acid for five minutes; but would recur as promptly if treatment were not continued several days longer. As a final step, the canal was sometimes painted with tincture of merthiolate, which seemed to help prevent reinfection, though it was ineffective for treatment.

In the mixed form, which often became manifest as the predominating factor cleared, many variations and combinations of these three basic treatments were used in the attempt to adjust to the course of the disease, especially alternating treatments at intervals of one or two days, and also swabbing with cresatin and packing with a sulfonamide ointment at each sitting when both exfoliation and cellulitis were observed. It was very obvious that the wrong treatment brought no results; especially the use of cresatin alone on cellulitis or a *B. pyocyaneus* infection or of a sulfonamide on fungus or *B. pyocyaneus* infections.

Dyes, such as gentian violet and Castellani's paint, were rarely effective and were used only in some few atypical and resistive cases, especially those with impetiginous lesions. Azochloramide was used in some atypical cases and seemed to have some effect, but not definite nor complete enough to convince one of its value or clarify its place in therapy.

Bland ointments, such as yellow oxide of mercury or vaseline, were useful upon abnormally dry but healthy skin. The skin of the external canal differs from all other in not being waterproof, its only secretion, cerumen, being water soluble; and petrolatum seems the best artificial protective coating we have when the effects of infection and the manipulations necessary to eradicate it leave this delicate skin unduly exposed.

Finally, it was observed that following every case of otitis media the external ear was left infected, quite commonly by *B. pyocyaneus*, and required appropriate treatment to clear the case completely.

In conclusion, we believe that external otitis is by no means a single disease cured by any one treatment, but a group of different infections requiring clinical identification, therapy based on classifi-

cation, and hygiene based on anatomical and physiological considerations to obtain and maintain control, particularly in tropical climates under military circumstances.

Since this paper was written the author has had opportunities to see further examples of the protean nature of this disease in a Naval Hospital on the Pacific Coast: particularly a crusting, impetiginous lesion which responded best to 5% ammoniated mercury ointment; and a dry, greenish crust spreading out over the concha, tightly adherent to a hyperemic but intact skin, with persistent wetness in the fundus of the canal, which fooled him for two weeks until suspicion of *B. pyocyaneus* finally dawned. The infection cleared in three days with the use of acetic acid.

U. S. NAVAL HOSPITAL.

### XXXIII

## MAXILLARY SINUSITIS OF DENTAL ORIGIN AND THE MANAGEMENT OF ANTRAL FISTULA

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Infections of the maxillary sinus secondary to dental pathology constitute one of the types of sinusitis which has not been given a great amount of consideration in otolaryngological literature. It has been estimated by various authors<sup>1, 2</sup> that from ten to twenty per cent of all chronic empyemas of the antrum have their origin in infected teeth. It is the purpose of this paper to discuss infections of the maxillary sinus which originate secondary to infections of the apices of the teeth adjacent to that cavity. Developmental abnormalities such as dentigerous cysts and adamantinoma are not considered within the scope of this study.

The anatomical relationships and development of the maxillary sinus have an important bearing upon the subsequent involvement of the antrum by diseased teeth. At birth the maxilla consists almost entirely of cancellous bone and the tooth buds are buried in its contents. The length of the alveolus is short so there is not enough room for all of the tooth buds in the alveolar ridge, but the posterior ones extend upward one on top of the other on the posterior upward extension of the alveolus. Later as the alveolus lengthens these buds extend downward and occupy their position in the ridge.

The maxillary sinus is present at birth but usually is only about the size of a pea in the body of the maxilla lateral to its ostium. The tiny cavity gradually increases in size by pneumatization of the cancellous bone until at about eight years of age the floor of the antrum is about on the level with the floor of the nose. By the process of pneumatization the bony walls of the sinus become thinner and also more compact. The antrum usually reaches its normal size in early adult life. As the sinus develops it comes in closer contact with the roots of the upper teeth. Occasionally the pneumatization is carried forward to the midline over the incisor teeth, but generally

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Presented as a candidate's thesis to the American Laryngological, Rhinological and Otological Society.



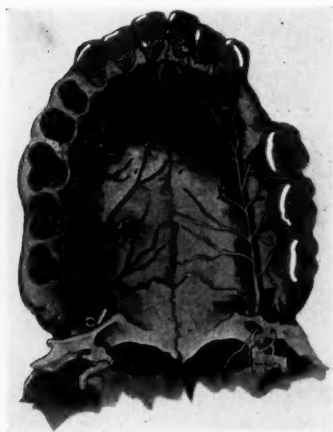


Fig. 1.—Sketch of the hard palate showing the course of the greater palatine artery and nerve.

the last five teeth, and particularly the first and second molar teeth have the closest relationship to the floor of the antrum and are therefore most frequently the offending ones in causing infection in that cavity.

By studying the development of the maxillary sinus it is readily understood why infections of that cavity are relatively rare in children. These infections are found more frequently in adults and particularly are more common in aged individuals in whom further absorption of bone has taken place and the incidence of dental caries is greater.

With the foregoing consideration of the relationship of the upper teeth and the floor of the maxillary sinus in mind, one can readily understand that an apical dental infection may extend through the thin bony floor of the antrum into that cavity. This is more evident in cases where a radicular cyst, probably resulting from chronic inflammation of the peridontal membrane, is present. There is usually a localized osteitis and periostitis with later involvement of the subepithelial stroma. This subepithelial stroma contains the vascular layer, fixed connective tissue cells and histiocytes, and underlies the ciliated columnar epithelium lining the sinus. The infection thus invades the mucosa first in the deeper structures thereby evading

the normal defense lines of the mucous membrane lining the cavity, namely the ciliated columnar epithelium and its protective mucous film. Because of this type of invasion it is found that the pathological destruction of the mucous membrane is much more rapid than when the sinusitis is secondary to an intranasal infection. The infection rapidly spreads throughout the subepithelial stroma, producing edema, infiltration of polymorphonuclear cells, round cells and exudate, eventually resulting in fibrosis and reduced blood supply to the overlying epithelium. The devitalized mucous membrane and bone necrosis produce putrefaction with the resulting characteristic odor found in sinus infections of dental origin. In the initial stages the defenses of the mucosa are overwhelmed. Later attempts of the mucous membrane to control the infection are manifested by the influx of phagocytic cells which tend to wall off the infection and often produce multiple localized abscesses and fibrosis in the subepithelial stroma. By this type of defense the toxic bacteria are retained deep in the mucosa and increase the morbidity and general systemic disability of the patient.

The clinical picture of the patient with a maxillary sinusitis due to dental infection varies somewhat from that of nasal origin.

#### *Maxillary Sinusitis of Nasal Origin*

1. There is preceding evidence or history of a nasal infection.
2. There is a tendency to be bilateral.
3. There is no history of dental disease or dental extraction.
4. Toothache may or may not be a symptom.
5. Pain or headache is usually referred to the supraorbital region due to blockage of the nasofrontal duct and nasal congestion or referred pain to the first division of the trigeminal nerve.
6. Nasal discharge is more profuse.
7. Nasal discharge is usually odorless.
8. Involvement of other sinuses, particularly the ethmoid cells, may be evident.
9. General systemic disability is not as marked as that seen in maxillary sinusitis of dental origin.
10. There is no x-ray or clinical evidence of dental infection.

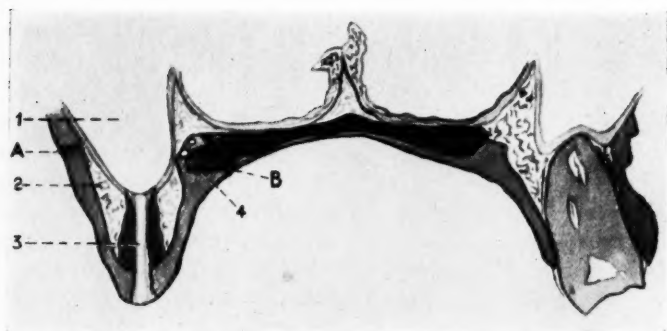


Fig. 2.—Cross-section through the alveolar process of the maxilla with the fistulous tract into the maxillary sinus showing the incisions on the buccal and palatine surfaces of the alveolar ridge. 1. maxillary sinus, 2. bony alveolar process of the maxilla, 3. fistulous tract, 4. greater palatine artery and nerve, A. buccal surface incision, B. palatine surface incision.

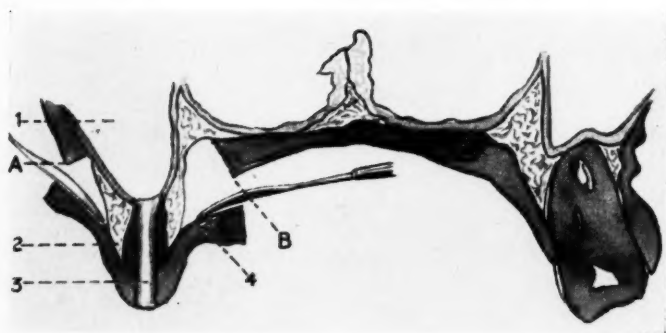


Fig. 3.—Cross-section showing the mucoperiosteal elevations in the preparation of the sliding flaps. This elevation is continued into the fistulous tract in the soft tissues on both the buccal and palatine surfaces. 1. maxillary sinus, 2. bony process of the maxilla, 3. fistulous tract, 4. greater palatine artery and nerve, A. elevation of the buccal flap, B. elevation of the palatine flap.

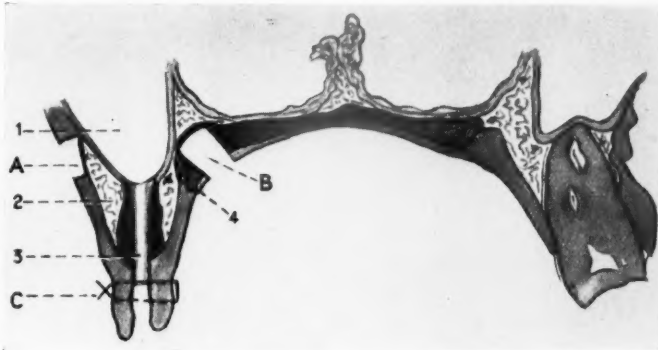


Fig. 4.—Cross-section showing the buccal and palatine flaps pulled down over the fistulous tract and closed with a horizontal interrupted mattress suture. 1. maxillary sinus, 2. bony process of the maxilla, 3. fistulous tract, 4. greater palatine artery and nerve, A. and B. the exposed bone of the buccal and palatine surfaces, C. fistulous tract closed by a mattress suture.

#### *Maxillary Sinus of Dental Origin*

1. There is no evidence of a preceding rhinitis.
2. There is a tendency to be unilateral.
3. Usually there is a history of dental disease or dental extraction; however, in the case of a nonvital tooth the patient may not be conscious of this trouble.
4. Toothache may or may not be a symptom.
5. Pain or headache is more likely to be confined to the antrum itself.
6. Nasal discharge is scantier early in the infection.
7. The nasal discharge has a foul odor due to localized bone necrosis and putrefaction.
8. Infection is usually localized to the antrum particularly early; however, later it may involve the adjacent paranasal sinuses.
9. General systemic disability is more marked than that seen in maxillary sinusitis of nasal origin.
10. There is x-ray and clinical evidence of dental infections.

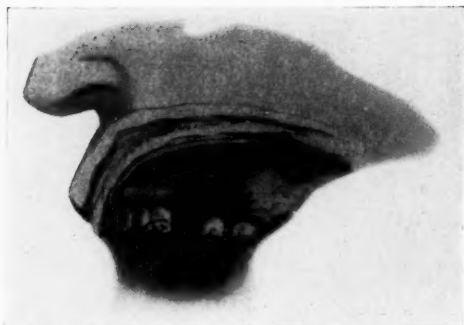


Fig. 5.—Lateral view of the incision in the hard palate area.

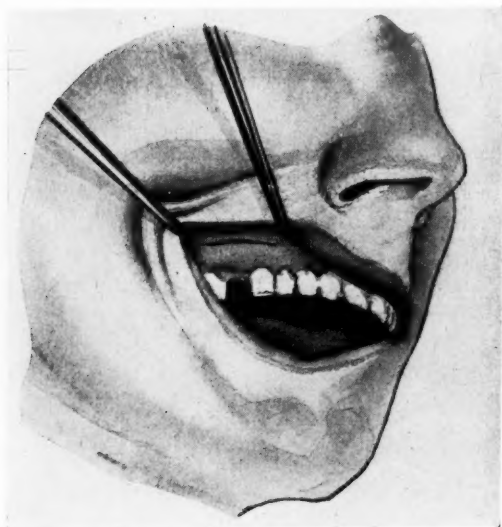


Fig. 6.—Lateral view of the incision on the buccal surface.

*Therapy:* The management of maxillary sinusitis of dental origin requires the close cooperation of the dental surgeon and the otolaryngologist.

These patients usually fall first into the hands of the dentist, who finds that after a tooth has been extracted the antrum has been opened and may already be infected. The sinus may become involved by contamination when attempts are made to explore that cavity by probing through the apical foramen and perforating the mucous membrane lining. The dentist often feels that he is at fault, perhaps blaming himself for cracking into the floor of the antrum, and he is hesitant to consult the otolaryngologist. Many dentists attempt to treat the sinus infection by irrigations through the oral fistula produced by the extractions. This type of treatment is often detrimental and may lead to the formation of a persistent fistula which frequently presents a considerable problem before a permanent closure is attained. With the knowledge of the close anatomical relationship between the dental apices and the floor of the sinus, it is readily understood that in cases of apical abscess or peri-apical infection the adjacent bony floor of the antrum may be necrotic and upon extraction of the involved tooth the overlying bony floor of the antrum may be removed with the tooth. If the pathological process has reached this stage, the dentist should not feel that he is at fault when the antrum is exposed and should seek the cooperation of the otolaryngologist in caring for the patient. It is the opinion of most rhinologists that these cases become a nasal problem as soon as the dentist is assured that all pathological dental tissue has been removed.

From the standpoint of the rhinologist most sinus infections of this type require about the same principles of therapy as those of nasal origin. However, it must be kept in mind that this type of infection invades the mucosa in its deeper structures and evades most of the defensive mechanisms of that membrane, thus producing a more severe type of sinusitis. Because of this the treatment must be more vigorous. A diagnostic irrigation of the maxillary sinus should be done by the intranasal method as soon as the infection is suspected. The return flow usually consists of a thin yellowish-green purulent exudate, almost devoid of mucous and having a very fetid odor. This condition requires frequent irrigations in the early stages in an effort to bring it under control and prevent the progress of the pathological process of the mucous membrane. If after six or eight antral irrigations the infection does not show signs of clearing up, an antral window should be made beneath the inferior turbinate. However, if the condition has not been treated vigorously early in the infection, the pathological process of the mucous membrane may progress rapidly



Fig. 7.—Lateral view of the hard palate showing the mucoperiosteal flap pulled down and the fistulous tract closed with a suture.

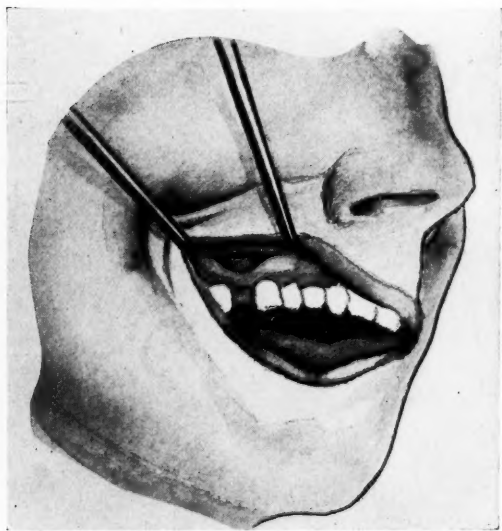


Fig. 8.—Lateral view of the buccal surface showing the mucoperiosteal flap pulled down and the fistulous tract closed with a suture.

and necessitate a Caldwell-Luc operation for complete exenteration of the diseased mucous membrane.

An alveolar fistula into the maxillary sinus following an extraction is not an uncommon complication. This, of course, occurs more frequently when the bony floor of the antrum is particularly thin, or has become necrotic around the apical infection and an empyema of the antrum already exists. Most of these fistulous tracts tend to close spontaneously if all of the dental caries are taken care of and the adjacent bony necrosis removed at the time of the extraction, and actual infection of the maxillary sinus has not taken place. In cases where the maxillary sinus has already become involved and ample intranasal therapy instituted without undue delay, and the infection brought under control, the antral fistula may promptly close. Sometimes the tract is successfully closed after a thorough curettement of the fistulous tract and the alveolar margins pulled together with a heavy black silk suture. However, this procedure often fails because the gum margins are under too much tension and the suture cuts out. Full thickness pedicle flaps from the hard palate or buccal regions have been used to close the fistula and have been more successful, but they have a tendency to slough and often fail to close the opening.

It has been my privilege for the last two and one-half years to be a member of the otolaryngological staff of a large hospital where there was an extensive dental establishment. In one year 50,025 teeth were extracted and 33,222 of these were due to periapical abscesses. We found that infections of the maxillary sinus of dental origin were quite prevalent, and those in which a persistent antral fistula was present were not uncommon. Several of the above methods were employed in attempting closure of the fistulous tract, and we finally found that a combination of full thickness soft tissue and periosteal flap from the hard palate and buccal surface of the alveolus to be the most successful.

First the fistulous tract was thoroughly curetted, removing all the epithelial lining, infected granulation tissue, or particles of necrotic bone. The sliding flaps were prepared by making an incision in the hard palate region (Figs. 2 and 5) about 2.5 cm. in length and 1.5 cm. above and parallel to the alveolar margin. This incision was made through the soft tissue and periosteum of the hard palate down to the bone. A similar incision was made on the buccal or external surface of the alveolus (Figs. 2 and 6), similar to the horizontal incision made in a Caldwell-Luc operation being only about 1.5 cm. from the gum margin. The periosteum was then elevated through these incisions on either side of the gum margin (Fig. 3) down to the opening in the gum margin. With this elevation accomplished the



soft tissue with the periosteum is pulled down on both sides until there is sufficient tissue to completely close over the bony opening into the floor of the antrum without being under tension. This is then sutured with a horizontal interrupted mattress stitch using heavy black silk (Figs. 4, 7 and 8). The bone exposed by the incisions and sliding of the flaps is left exposed and heals over readily by granulation and epithelization in a very short time. This operative procedure was done in eight cases and all wounds healed promptly.

The success of this method of closing an antral fistula is attributed to first making sure that all tooth fragments, infected granulation tissue, sequestra of the floor of the sinus, and epithelium lining the tract have been eradicated and that the infection of the antrum has been properly dealt with by intranasal irrigations, antral window or by exenteration of the diseased mucous membrane, as was indicated, before the effort was made to close the fistula. Next, this procedure insures an ample blood supply to the tissue involved. The palatine incision is made medial and parallel to the greater palatine artery and nerve (Figs. 1 and 2), which enters the soft tissue of the hard palate through the greater palatine foramen. This foramen is located in the hard palate about 0.5 cm. inside and opposite the last molar tooth. This artery and nerve course forward parallel to the gum margin (Fig. 1) and thus the blood and nerve supply is carried with the flap from the palate and decreases sloughing (Fig. 3), which is often the cause of failure in the pedicle type of flap. The relief of tension is another important feature of this method and is accomplished by the combination of the palatine and buccal sliding flaps. This procedure also reconstructs the normal tissues on the gum margin which after healing and recession allows dentures to be fitted more easily and satisfactorily to the patient.

#### SUMMARY

Infections of the maxillary sinus secondary to dental pathology are estimated by some authorities to constitute from ten to twenty per cent of the infections involving that cavity.

The anatomical development of the maxillary sinus and the relation to the adjacent teeth are reviewed.

It is emphasized that antrum infections of dental origin are more destructive because they evade the normal defensive mechanisms of the mucous membrane by first invading the subepithelial stroma.

The clinical picture of the dental type of sinusitis differs somewhat from that secondary to nasal infections.

The principles in the management of this type of case are discussed, particularly of those cases in which a persistent alveolar fistula into the antrum exists. The method of closure presented has several advantages over the more common methods now employed by most rhinologists and oral surgeons.

608 GUARANTY BUILDING.

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#### XXXIV

### ARTERIAL SPASM AND FAT METABOLISM; THEIR RELATION TO CERTAIN DISEASES AND TO CERTAIN MEMBERS OF THE VITAMIN B COMPLEX

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Blood vessel spasm is a very common condition, associated with many serious illnesses and often followed by sudden death. It is very definitely associated with very cold weather (polar infalls)<sup>1</sup> as seen in the northern middle states in our own country, and even here in California during the cold spells of December, January, February and March. The condition is also associated with emotional factors in individuals with an unstable nervous system (psychosomatic), and particularly also with the factors related to the metabolism of fat and probably also the metabolism of carbohydrates.

Persons with hypertension have rises in blood pressure during those periods of polar infalls. Deaf patients, especially those with the conductive type, have a drop in hearing; those having Ménière's disease also are worse during these periods. In fact, the original case observed by Ménière occurred in December.<sup>2</sup> Asthmatics, and frequently, nonspecific vasomotor rhinitis sufferers are definitely worse. Likewise, very serious sinus infections are of frequent occurrence, as is also the common cold. Probably all the different components of the vitamin B complex are involved in fat metabolism, i.e., thiamin, riboflavin, pyridoxine, nicotinic acid, pantothenic acid, choline, inositol, biotin, folic acid and the yet unknown factors.

Quite recently stress has been laid on the fact that choline, inositol, pyridoxine,<sup>3, 4</sup> and nicotinic acid have a definite vasodilator effect and recently, in the writer's hand, pantothenic acid has been added to the above. It may be that lack of these factors in the human diet is one of the principal causes of fatty livers as well as being responsible for the excess of cholesterol in the blood, in the absence of some endocrine factor, especially as in hypothyroidism.

*Nutrition Reviews* for April 1943 has a review entitled "Dietary Factors and Fatty Livers"<sup>5</sup> in which is mentioned the finding of Griffith and Mulford that the amino acid methionine is able to substitute for choline in the diet. Other authors referred to in this article tell us

how the other factors of the B complex are involved in fat metabolism. Emphasis has further been added to the choline question as follows: Choline is specifically associated with the abnormal accumulation of fat in the liver and it also has been found that choline requires the presence of inositol and sometimes pyridoxine to obtain its fullest effects.

The writer's studies have been confined—through microbiological analysis of the blood, in the Department of Home Economics, University of California in Berkeley—to the study of riboflavin, pantothenic acid and nicotinic acid. Thirty-seven cases have been studied. Of this number there are: 11 tuberculosis, 12 cardiovascular disease, 5 hypertension, 2 coronary disease, 3 arteriosclerosis, 2 intermittent claudication, 4 Ménière's disease, 1 migraine, 1 arthritis, 1 allergy, 2 tinnitus aurium, 1 nerve deafness, 4 no specific diagnosis. Of these patients, not including the ones having tuberculosis, 16 are under treatment. Of the tuberculosis patients, several are under treatment. Seventeen others, are under treatment for various disorders. All are taking a complete B complex preparation.

In all of these, riboflavin and pantothenic acid were found to be definitely below the accepted normals, but nicotinic acid was found below normal, or on the edge of normal in only three cases. Many of these patients showed also an increased blood cholesterol and in several the icterus index was above normal. In several cases, when possible, pantothenic acid as calcium pantothenate was administered intravenously, intramuscularly and by mouth, bringing the blood cholesterol to normal limits in five weeks. It appears from the unpublished report on the pathology of Agnes Fay Morgan's dogs deficient in pantothenic acid, that an extensive fatty infiltration was found in the liver, the kidney, and some in the heart. Hence, it appears that pantothenic acid is next in importance to B<sub>1</sub>, because it may be definitely related to the aging of man. In our series of cases, one patient aged 30, was definitely low in pantothenic acid, as well as riboflavin. Her physical disabilities have been definitely improved by the use of a tablet containing all the known B complex components. No investigation of adolescents has been made, but this deficiency has recently been found in a female aged 78 and her son aged 42, in both of whom a diagnosis of essential hypertension has been made.

#### PRINCIPAL FACTS CONCERNING FAT METABOLISM AND THE VITAMIN B COMPLEX

From a cursory examination of the literature, especially the *Annual Review of Biochemistry*, it appears obvious that fat metabol-

ism is related to all the known factors of the B complex, and this seems in the main to be supported by laboratory procedures.

*Thiamin* is definitely related to carbohydrate fat.

*Riboflavin* is definitely related to animal fat and occupies a prominent place in the various disorders of human beings as already mentioned in this paper.<sup>7</sup> And from recent reports it seems to be directly influential on hypertension, when deficient, through the conversion of tyrosine to tyromine by an enzyme related to riboflavin.

*Pyridoxine* is also associated with the utilization of unsaturated fatty acids.<sup>8</sup> Its use has been suggested for patients with oily skins and is also of value in acne. To what extent it actually appears in the subject under discussion is not at the moment apparent, though Engel thinks pyridoxine is necessary for the free lipotropic action of choline.

*Pantothenic acid* is definitely associated with the production of diffuse fat in the liver, kidney and adrenal cortex, and thus may play an important role in vasomotor instability. (These fatty changes are described in the unpublished report of the pathology of Agnes Fay Morgan's experimental dog, Benny.)

Through the adrenal cortex pantothenic acid may influence some of the electrolytes, especially sodium and potassium.

*Choline* is a very important factor in human life, and especially to the groups herein discussed. It is a vasodilator substance, like nicotinic acid, and along with the latter plays an important role in blood vessel spasm. The lipotropic action of choline<sup>9</sup> is specifically associated with the prevention of accumulation of fat in the liver. It is also thought to stimulate the formation of phospholipids. Choline has been found to be the special factor needed to pull vitamin A into the blood stream in cases of cancer of the intestine. And the writer has observed that a combination of the B complex containing choline seems to play an important role in the common cold, whereas vitamins A and D appeared almost ineffective.

*Inositol*. Both choline and inositol, present in the phospholipid lecithin and present in sizable amounts in soy beans, have a very definite influence in reducing the fat accumulation (cholesterol) in both liver and blood vessels.<sup>10</sup> Engel<sup>11</sup> thinks inositol more important than choline and more recently Beveridge<sup>12</sup> said: "It will be recalled that choline has a relatively greater lipotropic effect on the 'fat' fatty liver than on the 'cholesterol type of fatty liver,' whereas with inositol the reverse is true."<sup>13</sup>

*Biotin.* McHenry<sup>14</sup> and his co-workers say a different type of fatty liver is produced by biotin deficiency from that caused by choline deficiency. This is prevented by feeding lipocaic from the pancreas or inositol.

*Nicotinic Acid.* The particular role of nicotinic acid in the subject herein discussed is its relation to vascular spasm and thus is most important. In our laboratory studies so far only two cases have been found that approached the accepted lower line level. And thus it seems evident that it should be considered from its pharmacological, rather than its nutritional status. Atkinson has thus expressed himself in his discussions of Ménière's disease and quite recently Harris and Smith have come to the same conclusions. In a discussion on the "Pharmacodynamic Action of Vitamins" reference is made to niacin in the treatment of angina pectoris and further "doses of vitamins are employed which are far in excess of amounts required to produce changes in nutritional status."

Thus it appears that choline and nicotinic acid are the two known components of the B complex related to vasodilation. At present the association of nicotinic acid with fat metabolism is doubtful.

At the outset the application of microbiological methods to blood analysis was confined to the study of riboflavin, pantothenic acid and nicotinic acid because the work of Engel,<sup>11</sup> Best<sup>3, 4</sup> and others appeared to fix more or less definitely the relationship of choline and inositol to animal fats, especially cholesterol. Further, since an increase of cholesterol has been present in all cases studied so far, it has not appeared necessary to include the choline and inositol determinations in our studies. However, owing to the importance of choline in the relation of phospholipids to the cells of tuberculous tissue, these determinations are to be included in our laboratory procedures.

Also, since Martin<sup>7</sup> has produced definite hypertension in animals deficient in riboflavin but with increased tyrosine in the diet, Martin's method of tyromine analysis in the blood should definitely be included in coming laboratory studies.

#### *Methods Used in Microbiological Analyses.*

Pantothenic Acid: F. M. Strong, and R. E. Feeney, and A. Earle.

Riboflavin: E. E. Snell and F. M. Strong.

Nicotinic Acid: Krehl, Strong, and Elvehjem.

*Other Suggested Laboratory Procedures* are the determination of:

1. Basal metabolic rate
2. Complete blood count
3. Sedimentation rate
4. Vitamin A and carotene
5. Vitamin C
6. Cholesterol
7. Icterus index
8. Chlorides, sodium, potassium, calcium, phosphorus
9. Blood sugar
10. Urea nitrogen
11. When possible, choline-tocopherols, trace minerals and special amino acids
12. Acid base balance.

#### COMMENTS

From the data herewith submitted, it would seem that further, more complete laboratory studies of the blood of large numbers of patients (at least a hundred) with the various disorders mentioned are needed. With the obtaining of results in the majority of these cases similar to those already mentioned, a claim might be made that arteriosclerosis is a disease of fat metabolism as diabetes is a disease of sugar metabolism.

Many users of animal fats, i.e., milk, cream, butter, and egg yolk do not develop arteriosclerosis, coronary disease, or hypertension; nor are they victims of an inherited easily-disturbed vasomotor nervous system, or subject to anxiety states. Further studies may also show a more or less normal level of the various components of the vitamin B complex.

Two other interesting facts have developed in the past two years: First, choline has been found by Rhoads<sup>15</sup> to be the important factor in pulling vitamin A into the blood stream in cases of intestinal cancer and second, the writer has observed a definite increase of vitamin A in the blood. It is possible that choline will prove to be the most important factor.

It must not be forgotten that most degenerative changes are not often reversible, even in small degree, and that in order to accomplish any changes large doses of the various components of the B complex are necessary and have to be continued over a period of

many months and perhaps for a lifetime, just as occurs in hypothyroidism. It must be remembered also that even though no improvement takes place in the areas of degeneration, these patients are made more comfortable and approach old age with less physical discomfort than would otherwise be the case.

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FURTHER OBSERVATIONS ON THE KING OPERATION  
FOR BILATERAL ABDUCTOR PARALYSIS

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A sufficient period of time has elapsed since the original report by King<sup>1</sup> for the appearance of subsequent reports from him and others.<sup>2-16</sup> These reports contain some changes in technique, modifications, and in one instance, a new approach to the crico-arytenoid articulation. However, all these reports substantiate the fact that a procedure is available which can be expected to produce a high percentage of successful results. Unfortunately the literature seldom contains one source of evidence that is far more critical of the practical side of the results than is either the patient or the surgeon. This source of evidence is the friends and relatives of the patient. By proximity they were forced to share the discomforts of a tracheotomy tube or, in the untracheotomized patient, the hazards that surround an individual who has an inadequate airway. When the stamp of approval is obtained from this source as well as the patient, the results must be good.

## TECHNICAL CONSIDERATIONS

A moderate amount of experience with the procedure warrants some observations. Paradoxically, the value of the transplantation of the omohyoid muscle, as outlined by King, is a failure. The premise and conclusion of the problem rested in substituting an active accessory muscle of respiration for one that had become inactive because of loss of the nerve supply. There is now little question in his mind, and none in the minds of the other contributors, that the transplantation of the omohyoid muscle is unimportant. Under conditions of forced respiration the action of the muscle could not contribute more than one or at the most two millimeters of additional airway. During normal respiration its action is negligible. It is

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possible that the attachment of this muscle would help in maintaining the arytenoid in the abducted position. This is purely theoretical and is not worthy of further consideration at this time.

In order to maintain the arytenoid in abduction for a sufficient period of time to allow the attached end of the omohyoid muscle to produce a firm union, some means of relief from tension were necessary. He accomplished this by severing the fibers of the interarytenoideus muscle, disarticulating the arytenoid, and by means of a stay suture, fixing the arytenoid to the lateral wing of the thyroid cartilage. The degree of abduction depends upon the amount necessary to obtain an adequate airway. Theoretically this is correct and the results were good. Practically, as time has shown, the three important steps are:

1. The disarticulation of the arytenoid cartilage.
2. The freeing of the arytenoid from the tension of the interarytenoideus muscle.
3. The fixation of the arytenoid and the remaining attached tissue in abduction for a period of time to assure one that the scar tissue will maintain it in that position.

The three steps have proved to be the all important factors. They are responsible for the success of the procedure. The transplantation of the omohyoid muscle is not important.

The severance of the fibers of the interarytenoideus muscle is important. It has happened that an otherwise satisfactory result failed because of lack of attention to this detail. Immediately following surgery the laryngoscope revealed a cord in ample abduction and an adequate airway. Examination on the fifth postoperative day showed a minimal amount of edema of the soft tissues covering the arytenoid. The cord was in good position and the possibility of early decannulation was entertained due to the fact that there was at that time a 4-5 mm. available airway. On the ninth postoperative day the tracheotomy tube was corked. The airway was adequate and the patient spent a wholly comfortable afternoon and night. When seen the next day she stated that she thought she was catching a cold. The patient was correct. The presence of an acute upper respiratory infection delayed any idea of decannulation. As the next few days passed, respiration through the larynx became more difficult and by the fifteenth postoperative day it was evident that the airway through the larynx was not adequate. Examination showed no redness or edema of the laryngeal structures. There was a mere slit about one

millimeter wide between the cords. This was somewhat confusing until one oriented oneself. The transfixed right cord was in its proper position. The narrowing of the airway had been caused by the migration of the unopened left cord and arytenoid past the midline until it was almost adjacent to the fixed cord. There was nothing to do but wait a time with patience and then repeat the operative procedure on the left side. When for some reason both sides are subjected to surgery, the opportunity for obtaining or maintaining a voice of adequate volume and pleasant tone and timbre is almost nil. When a bilateral procedure has to be done to obtain an adequate airway both cords are of necessity fixed in a certain degree of abduction and such sounds as are produced are mainly from the false cords. This is never a pleasant sounding voice.

The selection of the site for the suture or sutures around the arytenoid cartilage is also important. The selection of the point on the thyroid cartilage for the anchorage of the suture and toward which or against which the arytenoid and attached structures will be pulled is not nearly as critical. A millimeter or two one way or the other apparently makes little difference. The placement of the stay suture is critical. The suture around the arytenoid must be at or slightly posterior to the processus vocalis. When properly placed, the tension moves the structure laterally and causes a certain amount of external rotation of the arytenoid cartilage. This is most desirable in that space is gained where it is most needed. If the suture is placed through the body of the arytenoid, the body will move lateralward, but frequently this movement is accompanied by an internal rotation. This defeats the purpose of the operation. The true cord is not pulled laterally more than one or two millimeters and that is not sufficient. Experience shows that no amount of tugging or pulling will compensate for poor placement of the suture. Fortunately the substitution of main force and clumsiness usually results in the suture tearing through the tissue and this permits the insertion of the next suture in the proper area. Naturally, this is not the accepted approach.

The placement of a second suture around the body of the arytenoid will, at times, assist in obtaining a desirable amount of external rotation and insure the maintenance of this rotation. A somewhat recent personal communication from Dr. King suggests a modification of the suture, but since there has not been an opportunity to give it a fair trial the details will be omitted. Attempts to place the second suture through the body of the arytenoid are successful in many instances but frequently result in fracture of the cartilage. The

cartilage is friable even when there is a minimal amount of calcification. Since it is technically less difficult and actually more efficient to follow around the cartilage in the submucous layer, that procedure should be followed.

The degree of abduction necessary to afford an adequate airway is never less than that sufficient to maintain a space of 3-4 mm. between the vocal cords during forced respiration; 4-5 mm. is better. Abduction greater than this carries with it the assurance of ease of respiration. If the distance between the cords is greater than 7 mm., the opposite cord usually falls short of relative approximation on attempted phonation and both cords fail to vibrate. When this obtains, the individual must be satisfied with a harsh whisper or compensate by using the false cords. The tonal qualities in the latter instance are far from pleasing to the listener's ear and are frequently lacking in carrying quality. This type of voice may be next to useless for telephone conversation.

In certain instances wherein the ultimate distance between the cords is not greater than 4.5 to 5.0 mm. and the quality and timbre of the voice is wholly pleasing, the individual finds that prolonged conversations result in considerable fatigue. This is easily explained by the fact that there is an excessive spilling of air during phonation and necessarily a greater expenditure of effort in an attempt to compensate for this loss. Similar difficulty may be encountered when the arytenoid and attached structures are raised or lowered more than two millimeters by being pulled in either of these directions by the stay suture. Undoubtedly there must be considerable leeway or this would occur more often. This possibility must be kept in mind when selecting the point for fixation on the thyroid cartilage.

There are considerable variations in the sizes and shapes of the thyroid cartilages. Theoretically the mechanical problems are fundamental and a matter of simple dissection and repair. Actually they must be sufficiently flexible to accommodate the individual anatomical variations and still produce results. With this in mind it is advantageous to examine the prospective candidate several times prior to the date of surgery. This should entail careful examination of the thyroid cartilage and surrounding structures by external palpation as well as a detailed visualization of the larynx by the indirect method. Indirect laryngoscopy permits examination of the action of the adductor muscles, an estimation of the available space and a rather definite idea as to the amount of abduction necessary for an adequate airway. The presence or absence of visible evidence of myxedema

of the intralaryngeal structures is important. The external examination will give considerable information as to the size and shape of the thyroid cartilage. The variations are not confined to the length and breadth of the thyroid alae. The anterior borders vary from a straight line to one with a marked concavity. As with most things, the individual variations become apparent only when they are subjected to detailed observation. Other variable characteristics of the thyroid cartilage present themselves and can usually be ascertained or at least suspected prior to the time of surgery. There are marked variations from a wide or narrow "V" to a "U" type.

In some instances the lateral borders curve inward toward the midline so that the general contour is oval. This latter condition proved to be most annoying in one instance. Sufficient abduction to afford an airway was not obtained although the arytenoid cartilage was fixed flat against the thyroid cartilage. The result at present is a failure. The revision of one of these procedures is undertaken with considerable mental reservation. It is technically a little more difficult in that there is some obliteration of the landmarks due to scar tissue. The additional effort is worth the opportunity of preserving a good voice. When the same side is re-used a good result will be obtained by removing the body of the arytenoid cartilage and abducting the soft tissues to the fullest extent. Or it is possible to remove a small section of the lateral edge of the thyroid ala so that the freed arytenoid may be pulled through the U shaped opening and fixed flush with the external surface of the thyroid cartilage. Either of these methods will obtain the additional 3 to 5 mm. essential for an adequate airway and will leave the adductor function of the opposite side unimpaired.

One must keep in mind that when the second side is used the possibilities and probabilities of a wholly useful voice are markedly diminished. Under all circumstances there is a compromise between the available airway to be obtained and the quality of the resulting voice. The trained ear detects certain changes in the voice of the individual with a bilateral abductor paralysis prior to any surgical intervention. There is always some voice change following the reconstruction surgery.

There is a certain thickness or fuzzing of the tone described by some as a "throaty" sound and usually a distinct loss in the tone range. A result such as this, combined with an adequate airway that permits more than average exertion without any dyspnea, should be classified as excellent. This is a small price to pay for the permanent physical

relief and mental assurance obtained. All the results will not be excellent. There are too many variable factors to permit any such hope. In all fairness the problem as to this compromise between an adequate airway and the voice should be frankly discussed with the patient prior to surgery. Fortunately, the question of mortality, other than that attending any surgical procedure, does not warrant any special consideration. The literature to date places it at zero.

The question as to whether or not the patient should be tracheotomized prior to the corrective procedure is an individual one and as such, left in the hands of the surgeon. The type of anesthesia has some bearing on the necessity of assuring an adequate airway prior to the major procedure. In a number of instances the patient will be wearing a tracheotomy tube when first seen. If intratracheal anesthesia is employed in these cases induction is by means of cyclopropane and oxygen mixture through the tracheotomy tube until there is sufficient relaxation to permit the introduction of the intratracheal tube through the larynx. When this tube is in place and functioning properly, the tracheotomy tube is removed. The skin surrounding this opening is prepared as for any surgical procedure and the opening closed by some temporary means. Sterile adhesive tape, a tent gauze sponge inserted in the opening and anchored to the skin by means of a small towel clip, or properly placed superficial skin sutures will close the opening so that it will not be a source of contamination. This area is then isolated from the surgical field by sterile drapes. There is usually some contraction of the stoma during the time necessary for the isolation, disarticulation and fixation of the arytenoid, but it is not sufficient to cause concern. A few moments of gentle pressure with the olive tip of the stylet of the tracheotomy tube allows insertion of a tube of similar size to that formerly worn by the patient.

The use of intratracheal anesthesia obviates the necessity of a previous tracheotomy to maintain an airway. It has certain advantages in separating the arytenoid cartilages and diminishing the tension necessary to move them from the midline. This also tends to put a certain amount of tension on the interarytenoideus muscle fibers and allows them to be cut as a distinct entity rather than a soft somewhat flabby mass. Intratracheal anesthesia in the untracheotomized patient has the additional advantage of allowing one to complete the extralaryngeal surgery in a surgically clean field. This obviates any possibility of contamination of the wound by secretions from a tracheotomy stoma. As soon as the extralaryngeal surgery is completed and the wound closed, a second incision is made lower down

in the neck. A tracheotomy opening is made using the second, third or fourth tracheal rings as the anatomy of the patient permits. Both incisions used follow the natural skin lines and leave cosmetically correct scars. The upper incision extends from the middle of the sternocleidomastoid muscle of the selected side to a point 2 or 3 cm. past the midline between the lower border and middle of the thyroid cartilage, in other words, a modified Kocher incision centered over the lower third of the thyroid cartilage. The incision for the tracheotomy is likewise horizontal, is placed so as to allow the tube to rest in place without undue tension or distortion of the tissues and follows the natural skin lines or creases. In that the tracheotomy is not made with the idea of being permanent, it is not necessary to use a tube larger than No. 4 or No. 5. This is sufficient to maintain effortless respiration. The employment of the Kocher and modified Kocher incisions does not diminish the field of exposure. The resulting scars are far less obvious than when a vertical or longitudinal incision is used.

This procedure has been followed a sufficient number of times without complication to permit the conclusion that a preliminary tracheotomy is not necessary when intratracheal anesthesia is used. It does not obviate the necessity of two scars but it does relieve the patient from the psychic trauma attending two surgical procedures. Intratracheal anesthesia should not be attempted by anyone other than a well-trained competent anesthetist. The use of an intratracheal tube through the larynx has shortcomings. Observation of the vocal cords is somewhat cumbersome. The immediate laryngeal picture can lead one astray with a false sense of security. When the standard sized tubes are used they exert sufficient pressure to bring about considerable dilatation of the larynx. Thus, when the tube is removed there is a large airway. The space appears to be more than ample. Close observation shows that the unoperated cord is in a fair degree of abduction. If there is any question in one's mind that the fixed cord has been abducted too much, it is well to wait a few minutes until the anesthetic can be lightened enough to permit some laryngeal response. Then the unoperated cord will assume its former position near the midline. If, after this occurs, there is still more space between the cords than is deemed compatible with a useful voice, one may toy with the idea of slackening the stay suture. This is said advisedly in that except for the individuals whose thyroid cartilage margins are naturally wide apart it is difficult to obtain an excessive degree of abduction when the arytenoid cartilage is not removed. It is better to spend a short time worrying about the voice than a much



longer period in unsuccessful attempts at decannulation and the ultimate decision that further surgery is necessary.

The use of intravenous or local anesthesia generally necessitates a preliminary tracheotomy. The preoperative medication deemed desirable is usually sufficient to produce considerable respiratory depression. This, coupled with the problems of laryngospasm, encourages one to enjoy the comfort of the knowledge that the tracheotomy tube assures an adequate airway. It is an easy portal for the administration of oxygen, if necessary. If the tracheotomy were only necessary for the short time of the actual surgery one might be willing to make certain concessions or changes in technic. Since this is not the case and the tracheotomy is essential as a means of respiration for several days following the operation, a preliminary tracheotomy is advisable if one is to employ anesthesia administered by any method other than by means of an intratracheal tube inserted through the larynx. The use of local or intravenous anesthesia does permit the use of the coagulating current.

Numerous other technical points come to mind. A few will be mentioned briefly, others purposely omitted. A nasal feeding tube is not necessary. The patients have all been able to swallow without difficulty as soon as they have regained consciousness and recovered from the effects of the anesthetic agent. This was classically demonstrated by one patient who had received not only the full quota of special gastrostomy diet formula by tube but through some error was served a regular diet tray. When seen shortly after she had eaten the food she whispered that she felt very full, and that although the tube in her nose that went down her throat was slightly uncomfortable, it really did not bother her a bit. Since that experience, the routine installation of a nasal feeding tube has been deleted. If there is any question of inadequacy of fluid intake it is corrected by intravenous five per cent glucose in salt solution. Thus far the fact that the patient has used the muscles of deglutition has not produced any effect on the success or failure of the ultimate results.

The question as to whether the patient should be allowed to talk immediately after surgery has been brought up for consideration. This is no problem with patients who have not had a preliminary tracheotomy. Until they are introduced to the fact that they can make a noise by inspiring and then plugging off the tube with a finger, they are resigned to communication by gesture and the written word. In those patients who have had a preliminary tracheotomy and have learned to plug off the tube some difficulty is encountered in dis-



suaing them from attempting some conversation. Even the least inquisitive admit some degree of experimentation just to see if there is a voice. There is no real reason for being arbitrary on this point. Some of the patients having the best results talked more or less as they desired during the postoperative course while some of the less successful results were obtained in individuals who remained aphonic during this period.

Likewise there is no fixed time for decannulation. The amount and duration of the postoperative edema is the determining factor. The tracheotomy tube should not be removed until the patient has allowed the tube to be continuously plugged for 48 hours and has demonstrated both subjectively and objectively that the tube is no longer a necessity. Attempts at decannulation should not be instituted prior to the fourth or fifth postoperative day. Occasionally the persistence of edema of the arytenoid and the cord will delay the removal of the tube for as long as three or in one instance, four weeks. This is not a common occurrence. If at the end of three weeks an adequate airway through the larynx is not present or ascertained by the image in the laryngeal mirror showing a space of at least 4 or 5 mm., the results of the surgical procedure can be considered a failure. There is one possible exception. Should it so happen that the mucous membrane covering the arytenoid has been perforated or torn, as has been reported, it is possible that infection of the mucoperichondrium is established. One can then wait a longer period before concluding that the ultimate result will be a failure.

The presence of an adequate airway does not always assure uncomplicated decannulation. Two types of patient are troublesome. One is the typical neurotic who has to be carried through all types of any procedure on one's back just as a general principle. The other is represented by a small percentage of the group of patients who have worn tracheotomy tubes for many years. These individuals carry with them psychic scars as a result of harrowing experiences associated with the inability to get sufficient air prior to the tracheotomy. Any discomfort in or about the larynx or, with some, even the thought of a garment with a snug-fitting neckband is ample stimulus to initiate certain phases of suffocation. In addition, some of these individuals have breathed by means of a tracheotomy tube for so many years that they have forgotten the sensation produced by the inspiration of air through the larynx. Nor do they remember that a certain amount of muscle effort is necessary to breathe through one's larynx. If the laryngeal airway is adequate all of these patients can be decannulated with safety. Often this entails the expenditure

of considerable time and much patience. The surgeon can anticipate hearing from these patients, usually at night, at decreasingly frequent intervals for several months. Any psychic upset may initiate a sensation of inadequate airway. If the patient has sufficient airway to carry on a prolonged telephone conversation, there is no immediate danger.

The advantage or disadvantage of removing the arytenoid cartilage is essentially technical. If one follows the general outline of procedure proposed by King<sup>1</sup> and approaches the area from the posterior and interior surface of the thyroid cartilage, there is no reason to maintain that the arytenoid should be removed as a part of the surgical routine. In fact there are several good reasons why its presence should be advantageous. There is no cause for despair should it so happen that the arytenoid cartilage is so badly fractured during manipulation or so isolated by dissection from the surrounding tissues that it is little more than a foreign body. The proper thing to do under these circumstances is to remove the semi-attached fragments or the entire body of the arytenoid cartilage and continue on with the procedure. The removal of the arytenoid has not produced an unfavorable result. The correct placement of the stay suture is a little more difficult. In one instance previously mentioned there was little space between the lateral border of the arytenoid and the inner wall of the thyroid cartilage due to the inward curvature of the latter. Hind-sight shows clearly that the intentional removal of the arytenoid would have been advantageous. Should a similar condition arise, the arytenoid will be removed purposely.

When one follows the procedure outlined by Kelly<sup>2</sup> wherein the arytenoid is approached by way of a window through the thyroid cartilage, the removal of the arytenoid is usually essential. The exposure by this method is not sufficient to routinely permit the necessary steps for correction and leave the arytenoid attached to the thyro-arytenoideus and crico-arytenoideus lateralis muscles. One of the main points of this approach is that considerable space is obtained by the removal of the main body of the arytenoid. Whatever vacant area is left between the retracted vocal cord and the thyroid cartilage will be filled with scar tissue which in turn will aid in keeping the cord abducted.

The advantages of the Kelly procedure are well outlined by the author.<sup>3</sup> The disadvantages of working through a relatively small aperture in the thyroid cartilage are stated honestly but are not given as much emphasis as seems proper. First, no mention is made of

the variations in size and shape of the thyroid cartilage. The majority of the corrective procedures will be done on females and in some the thyroid cartilage is quite small. Second, the available exposure through a three-eighths inch square opening, when working under ideal conditions, leaves much to be desired. This is evident even when using fresh cadaver material wherein bleeding and muscle movement are absent. Third, the opportunity of perforating the laryngeal mucosa while dissecting the arytenoid or placing the suture is greater due to both increased mechanical and diminished visual factors. The frequency of this happening is evidenced by the author's<sup>6</sup> comment:—

"In the first few cases we did not give much thought to sewing the mucous membrane of the larynx after it had been injured; now we are very careful to do so and also to put some fine catgut sutures through the frayed fibers of the arytenoid muscle."

These observations on the Kelly technique are the result of purely academic experience wherein fresh cadaver material was used. The conclusions are personal and as such open to criticism. However, the dissections were done under ideal conditions in the hope that the technique would eliminate some of the more difficult phases encountered in the King operation. Such was not the case.

Whether one approaches the larynx from the right or left side is a matter of personal choice if all other factors are equal. It seldom occurs that all the other factors are equal. The surgeon should be able to approach either side with equal comfort. Certain factors should decide the side to be approached. If there is a difference in the mobility of the two cords, the more immobile of the two should be used. If there is a preexisting paralysis of one side and a bilateral paralysis follows thyroidectomy, the side with the preexisting paralysis should be used. This has the advantage of allowing the return of function of the last involved cord should it be one of those rare instances wherein delayed return of function takes place. This cord will then be able to carry on the burden of phonation.

This brings to mind the selection of the time for the corrective surgery. Wright<sup>11</sup> states:

"The operation should be performed only in those cases in which bilateral abductor paralysis has existed for six months or longer. It is seldom that function of the cord returns after six months, though a few cases have been reported."

Taken by and large the advice is correct. The only reason for waiting this period of time is in hope that the last involved cord will return to function and thereby relieve the patient from a second

surgical procedure. There are a few instances that permit the surgery to be done at a much earlier date. Early correction is advocated when there is preexisting abductor paralysis in one side and the thyroid surgeon admits the knowledge that the recurrent laryngeal nerve on the functioning side was either cut or so severely damaged as to be made useless. At one time the proposal was made that should such a condition be anticipated it would be propitious to have on call some one qualified to do the corrective procedure immediately following the thyroidectomy and prior to closing the wound. The idea is intriguing. It would obviate a second operation, but is not sound. If the thyroid surgery is uncomplicated, the nerve is not injured. If it is complicated and the nerve is injured, the addition of the corrective measure is too much surgery at one time for the welfare of the patient. A satisfactory compromise has been attained by the sincere plea or demand, as the case may be, that the patient be tracheotomized prior to closure of the thyroid wound. This eliminates hours of partial asphyxia and then tracheotomy as an emergency measure. It has happened that a delay in tracheotomy has so depleted the reserve of a patient that the ultimate adequate airway did not suffice to relieve a worn out myocardium. The corrective surgery should be done as soon as the patient's general condition will permit. If this occurs prior to the end of the second postoperative week, one can avoid making a second incision by using the thyroidectomy wound. In one instance of marked malignancy of the thyroid the extensive dissection necessary resulted in bilateral abductor paralysis. The corrective procedure was done on the eighth postoperative day. The thyroid wound was used to definite advantage. The larynx and the trachea were practically skeletonized. It was a pleasure to start in with the terminal phases of the corrective procedure with excellent exposure and a dry field and to have both with so little effort. Had this second operation been postponed for six months the difficulty in obtaining exposure would have been complicated by extensive scar tissue. This can only be appreciated by those who have had the experience of trying to obtain adequate exposure in patients who have had multiple thyroidectomies.

With but one exception the patients with bilateral abductor paralysis who reported or were referred for advice for corrective measures had had one or more thyroidectomies. There are other causes of bilateral abductor paralysis. Certain lesions of the central nervous system, infection, and an occasional rare case as a result of trauma account for the remaining cases. Those of central nervous system origin seldom experience much difficulty with respiration due

to the fact that the cords usually are at, or near, the cadaveric position. The cords are flaccid, show marked atrophy and actual loss of tissue substance and are either useless as a source of sound or tire easily in attempted phonation. Persistent hoarseness or aphonia of varying degrees and duration encourages the patient or his physician to request a diagnosis. Those of traumatic origin have a definite cause-and-effect history and offer no problem other than the immediate necessity for an airway or appropriate corrective measures. Those due to infection are the result of perichondritis and secondary ankylosis of the crico-arytenoid joint. The *Mycobacterium tuberculosis* and the streptococci are the more common invaders. The unbalanced ratio of adductors to abductors results in the cords approaching the midline and thereby diminishing the available airway. Myerson<sup>12</sup> reports on one case of fixation of the crico-arytenoid joints due to streptococcus infection.

Thus far arthritis has not been mentioned as a source of laryngeal difficulty. The case history of one patient is of sufficient interest to warrant the presentation of a somewhat abbreviated abstract.

#### REPORT OF CASE

When first seen this woman was brought into the office in a wheel chair. Plugging of the tracheotomy tube resulted in crowing sounds and respiratory distress. Examination of her larynx by the indirect method showed a bilateral abductor paralysis.

March 30, 1943, the patient entered University of California Hospital for a King operation.

*P.I.* Severe, crippling, symmetrical, generalized arthritis. Onset ten years ago. Associated with early menopausal symptoms. The condition has been relentlessly progressive in spite of remissions and has not responded to various forms of therapy including tonsillectomy, typhoid pyrotherapy, streptococcus vaccine, vitamins, calcium, gold, proprietary mixtures and a sojourn at a mineral springs. The poly-arthritis is symmetrical and involves both the lower and upper extremities. Ten months prior to entry and near the end of a ten weeks' course of gold therapy she encountered some respiratory difficulty. This was of a wheezing character and it did not respond to routine therapy for asthma. The advent of an acute upper respiratory infection made breathing so difficult that a tracheotomy was imperative. This was ultimately done as an emergency procedure. One month prior to entry an attempt was made to decannulate the patient. This was unsuccessful.

*P.H.* Exceptionally healthy until onset of arthritis ten years ago.

*F.H.* Negative.

*P.E.* Tracheotomized female who appears somewhat older than stated age of 52 years. The rest of the findings including the laboratory and x-ray report are unimportant except for:—Joints; a striking thing about the involved joints is the marked cartilaginous destruction. The fingers are shortened, subluxed, and some are fused; two in complete hyperextension. Feet: there is marked subluxation of

toes with metatarsal heads immobile and thrusting against plantar surface. Hallux valgus with exostosis about the first metatarsal joints. Larynx: the general appearance of the tissues is good. The vocal cords are near the midline and are separated by a space of not more than 2 mm. They meet in the midline on phonation. Vigorous attempts at forced inspiration resulted in slight adduction, no abduction. At no time during this examination or previous examinations was there abduction that permitted a space of more than 2.5 mm. between the cords. The voice was of good quality.

*April 5, 1943.* King operation performed.

*April 20, 1943.* The tracheotomy tube was plugged. There was no difficulty with respiration.

*April 23, 1943.* The tracheotomy tube was removed.

*April 29, 1943.* To surgery for plastic closure of the tracheotomy fistula and removal of as much of the tracheotomy scar as possible. Nitrous oxide and oxygen, by means of a mask, was used for anesthesia. There was no respiratory difficulty.

*May 6, 1943.* Discharged from the hospital. There was a hair-line scar where the incision was made for the King operation and where the tracheal fistula was removed. There remained a somewhat unpleasant vertical scar that marked the incision made at the time of the emergency tracheotomy. There was a wholly adequate airway and an excellent voice. Laryngeal examination on this date showed the right cord abducted and fixed. On quiet respiration there was a space of at least 4.5 mm. between the cords and this space was not diminished by forced respiration. Attempted phonation showed the left cord to move past the midline and approximate the right cord.

The patient was seen at infrequent intervals after this date until May 1944, when she returned to the hospital for corrective measures for arthritis. During the year May 1943-1944, the involvement of the joints of the extremities, especially the feet and knees, had progressed to a point where she was no longer able to endure efforts to move about with the aid of a walking chair and was either confined to bed or was pushed around in a wheel chair. She was hospitalized from May until November, 1944, received adequate medical and orthopedic care and, on discharge, was able to walk out of the hospital. This period of hospitalization allowed an opportunity to observe the larynx at will, ascertaining the adequacy of the airway and the voice under a variety of conditions. There was no diminution in the space between the cords and the voice was actually better than it had been the year previous.

During this hospitalization the patient contracted a severe upper respiratory infection and an acute laryngitis. The laryngeal picture differed in no way from the routine one. The cords were first fiery red, then thick and edematous. They returned to normal at the end of one week. The onset of aphonia caused considerable psychic upset in the patient for fear that her voice would not return and later, fears that the airway would not be sufficient. In that a similar set of symptoms preceded the emergency tracheotomy she had ample grounds for her fears. Fortunately there was no difficulty with respiration even when the swelling and edema of the cords were at the peak. With the subsidence of the swelling and edema of the vocal cords the voice returned to normal.

*Comment:* The surgical procedure of the King operation offered two points of interest. First, the dissection down to the arytenoid

was the easiest yet encountered in a living subject owing to the fact that the area had not been subjected to previous surgery. The various anatomical landmarks were as clear-cut as the illustrations in the book and as easy to locate as the written descriptions would lead one to believe is routine. Second, a normal appearing crico-arytenoid articulation was absent. Traction on the arytenoid by means of a small, sharp-pointed, curved hook showed marked limitation of lateral motion. This was further confirmed by digital examination. Instead of seeing the smooth glistening articular surfaces of the arytenoid and cricoid cartilages come into view when the capsule of the joint was incised, the surfaces appeared dull and rough and were attached to one another by numerous small strands of fibrous tissue. When the disarticulation was complete the entire articular surface of the arytenoid and a less extensive but representative specimen from the cricoid was resected at a depth of 1 mm. The cut surface of both the cricoid and the arytenoid had the appearance of normal cartilage. This finding dispelled any doubt that by some technical error the true articulation had not been found. These resected pieces of tissue and representative sections from the posticus muscle were sent for histopathological examination. A further request was made that some of the slides be run through special staining to ascertain the presence or absence of colloidal gold. The report states:

*"Gross description:* The specimen consists of several nondescript pieces of tissue."

*"Microscopic descriptions:* The specimen consists of striated muscle and fibrocartilage. The sarcolemma is prominent and apparently proliferated in some areas. There is evidence of some round cell inflammatory reaction. The muscle tissue shows areas of distortion, variation in staining plus some fibrosis, pyknosis, and agglutination. The nerve elements have greatly shrunk away from their fibrous sheaths and often appear hydropic and degenerated. The cartilage is well formed and presents no granulation or inflammatory reaction. A synovial surface is not found, even after recutting.

*"Diagnosis:* Striated muscle showing fibrosis, atrophy, and nerve degeneration with slight inflammation. Fibrocartilage from larynx."

The special straining methods did not reveal any evidence of gold. This report confirms the clinical diagnosis as to arthritic change and inactivity of the crico-arytenoideus muscle. In all fairness this case might well be diagnosed as secondary bilateral abductor paralysis, the paralysis being the result of degeneration due to disease. However, this point will be reserved as subject matter for the purist. The clinical picture is distinct and contains all the criteria essential for classification with uncomplicated bilateral abductor paralysis.



## Tabulation of Cases

TOTAL NUMBER	SEX		RESULTS		MORTALITY
	FEMALE	MALE	SUCCESS	FAILURE	
23	22	1	20	3	0

The tabulation of the numerous other factors such as the age of the patient, the number of thyroidectomies prior to admission, the duration of the paralysis, and the side of larynx used for operation, is neither interesting, necessary nor valuable to the reader. It is possible that the terms "success" and "failure" warrant some definition. In this tabulation a postoperative result is considered successful when it provides an adequate airway, a decannulation of the patient, and a useful voice. An adequate airway must permit comfortable respiration for routine daily life and sufficient reserve to allow for the unavoidable occasional extra demands. A useful voice is one that permits comfortable conversation and use of the telephone. If any or all of these three are not obtained, the result is classified as a failure.

## DISCUSSION

The importance of competent examination of the larynx and a written report of these findings prior to final arrangements for all thyroidectomies should be evident. This offers a degree of protection to both the patient and the thyroid surgeon. If it so happens that the candidate for surgery has one paralyzed cord, it is often possible to avoid injuring the recurrent nerve on the functioning side by certain changes in the technical routine of thyroidectomy and the exercising of more than usual care in the performance of the surgery. The patient should be informed of the presence of unilateral paralysis and advised that injury to the functioning side may occur in spite of every effort to avoid injury to the nerve on that side. The preexisting paralysis of one vocal cord, whether due to pressure or the result of previous thyroid surgery, indicates that the subsequent thyroid surgery will of necessity be more extensive than is the routine in the uncomplicated case. Therefore, the surgery will carry with it greater opportunity for laryngeal complications.

The necessity of a thorough physical examination and work-up from a medical point of view of the patient with bilateral abductor paralysis should not be minimized. A basal metabolic rate determination plus sufficient biochemical determinations should be done to establish as closely as possible the function of the remaining active thyroid tissue. The possibility of diminished function of the parathyroid



tissue must be kept in mind. Extensive thyroid surgery frequently includes two or more of the parathyroid glands. Some care must be exerted in making a diagnosis of hypoparathyroidism. It must be remembered that all these patients suffer from some degree of chronic oxygen hunger. Even the patients who have been tracheotomized show evidence of anoxemia. Individuals in this latter group should not and usually do not present as clear-cut evidence as the untracheotomized group, yet certain numbers of both groups hyperventilate to a point of unconsciousness. Some show evidence of tetany. Whether this central stimulation is the result of the chronic lack of oxygen or the inability to use it economically or whether the change is the result of the preexisting thyroid pathology is an interesting but as yet unsolved question. Further work will be done on this phase. If possible the thyroid-parathyroid needs of the patient should be stabilized prior to performing the larynx reconstruction and should be watched carefully thereafter.

The time spent in following the medical phase of these patients and in discussion of the problem with the clinician both before and after the corrective surgery is well spent. The changes brought about by the administration of thyroid extract dihydrotachysterol, calcium or other supplementary factors are frequently sufficient to decide whether or not the patient may resume normal status in the community. The complaint of diminishing ability to get sufficient air during the climbing of the third and fourth flight of stairs may be predicted if one will follow the increase in weight frequently following the corrective surgery. Increased food intake resulting from a general feeling of well-being may account for the weight increase in some individuals but is far from the complete answer in the majority. The number of times an individual will make a public spectacle of oneself as a result of hyperventilation can be diminished or eliminated by proper care. This usually entails direct therapy as well as complete understanding by the patient that psychogenic factors play a role. The psychic disturbances are real. In many instances the physiologic deviations from normal as shown by the laboratory tests may not be sufficient to indicate the necessity of supplementary therapy. The reactions of the patient are more important. If there is clinical evidence of hypothyroidism or hypoparathyroidism appropriate therapy is indicated in spite of the laboratory results. The response to supplementary therapy is often spectacular. In recent publications Holinger<sup>14, 15</sup> has stressed these points.

This is a brief exposition of some of the general considerations that are essential for the comfort of the patient. There are other

ramifications too numerous to include at this time. The problem is not entirely one of simple mechanics attending the production of an adequate airway. Attention is focused on this particular phase because it is so evident. When this has been corrected, the other phases become the objects of interest as they arise. Anticipation of these other phases and correction prior to their assumption of importance is the correct approach. It is important to remember that one is dealing with a biologic unit and not a group of assembled parts.

#### CONCLUSIONS

1. A procedure for correction of the difficulties attending bilateral abductor paralysis is available and has given a high percentage of good results.
2. The methods of approach as outlined by King and Kelly have been given consideration.
3. The method outlined by King is given preference, due to better exposure of the crico-arytenoid joint without arytenoidectomy.
4. Certain minor changes in the technic of King are suggested.
5. The transplantation of the omohyoid muscle is not essential to successful results and may be eliminated as a part of the corrective measure.
6. A preliminary tracheotomy is not essential if intratracheal anesthesia is used. Certain disadvantages of intratracheal anesthesia are discussed.
7. Criteria for the classification of the postoperative results as success or failure are presented.
8. Sixteen cases are added to a former report. This makes a total of 23 cases, 20 successful results, 3 failures. The mortality rate is zero.
9. One case of bilateral abductor paralysis due to rheumatoid arthritis is presented. The clinical course and histopathological report are of interest.
10. The correction of the mechanical factor in the larynx is of importance but not the sole factor in the rehabilitation of these patients.

490 POST STREET.

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## SPASMODIC FACIAL NEURALGIA

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It is recognized that pain in and about the face occurs in disorders of entirely unrelated nature. In many of these, such as acute inflammatory processes and tumors, the pain is not characteristically paroxysmal or neuralgic. In others, as *tic douloureux*, the pain has these qualities largely or exclusively. But whatever the etiology or type of pain a neurological approach to its understanding is of considerable value. This is because there can be no appreciation of pain without participation of the sensorium. The pain stimulus initiated peripherally must travel centrally to higher nervous areas before it is perceived as pain.

There are several different pain pathways from the general region of the face to the sensorium. In primary neurological disturbances the lesion lies somewhere along one of these pathways, and its site and nature must be determined. In peripheral painful lesions, not neurological, the same pain pathways are utilized. This fact has a definite therapeutic application because, when the lesion cannot be dealt with successfully, the pain it produces can be abolished by interrupting the appropriate pain tract to the brain.

Fundamental then in the diagnosis of pain in and about the face are: the pain path affected, its point of involvement, and the nature of the irritant.

The chief routes of pain from the general region of the face to the sensorium are:

1. Trigeminal nerve (brow, eyelids, nose, cheek, lips, chin, part of ear, nasal fossa, palate, anterior two thirds of tongue).
2. Facial nerve (part of auditory canal and tympanic membrane through the nerve of Wrisberg).
3. Glossopharyngeal nerve (posterior one third of tongue, tonsil, faucial pillars, soft palate, pharynx, eustachian tube, tympanic cavity, mastoid cells).

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4. Vagus nerve (part of auricle and of external auditory meatus through the nerve of Arnold).
5. Small occipital nerve (part of pinna).
6. Great auricular nerve (part of auricle, angle of mandible).
7. The sympathetic.

A pain stimulus may be applied at different points along any one of these structures—peripheral nerve branch, ganglion, ganglionic or spinal root. In the not infrequent cases of trigeminal neuralgia following dental extractions the stimulus is probably peripheral. In ophthalmic and geniculate herpes zoster the point of irritation is at the level of the ganglion. The ganglionic root is involved in cases of cerebellopontine angle tumors or syphilitic basilar meningitis with pain in the area of distribution of the fifth or ninth nerves. A high cervical intraspinal tumor can cause pain in the auricle by irritation of the roots of the cervical plexus. In general diagnosis of the site of irritation of the pain tract depends upon the presence of associated neurological findings.

Pain elaborated at the psychic level—so-called psychalgias, but better labeled as plain hysteria—also occurs, and at times is easily confused with an organic neuralgia.

The nature of the irritant, the lesion or the underlying pathological-physiological process, cannot be identified in numerous cases. This is because the essence of many neuralgias is obscure. However, a certain differential classification, necessary for proper treatment of the patient, can usually be made. To succeed in this the clinician must heed certain points. Of these the most important are: 1) precise location of the pain, 2) character of the pain, 3) its mode of occurrence, 4) its relation to various external stimuli and to acts involving muscles of the face, jaw, tongue, and throat, 5) the patient's general behaviour during the time of pain, 6) specific features characteristic or highly suggestive of well-known clinical syndromes, and 7) associated neurological findings.

Of prime importance is precise location of the pain. A pain constantly recurring solely in the domain of a particular nerve indicates involvement of that nerve—and no other. Should the pain spread beyond the limits of the nerve's distribution the condition is something other than a simple neuralgia. This point is helpful, for instance, in differentiating trigeminal tic douloureux from migraine or from hysterical pain in the face. In true tic the pain is confined

to the area of one fifth nerve, and is rarely bilateral. In migraine the pain may be predominantly frontal and unilateral, but it not infrequently will shift to the other side. Psychogenic facial pain may spread from the face to the back of the head, the throat or the shoulder.

In various entities there is a difference in the quality or character of the pain. That of neuralgia is sudden in onset, brief in duration, lancinating, severe. It comes swiftly, goes swiftly. There may be a few or countless such pains a day, but they are alike and between them is an interval, long or short, of comfort. Of a different breed is cranial or facial migraine, less lightning-like in its appearance, remaining interminably; no quick lash of pain, but a steady, sickening ache; no intervals of relief.

The mode of occurrence varies, too. *Tic douloureux*, Horton's histaminic cephalalgia, and migraine all occur paroxysmally. But the bouts of tic pain last days, weeks or months, and each consists of a succession of knife-like jabs. Horton's cephalalgia usually persists a month or two, and is made up of a series of brief, intensely severe headaches. These frequently appear during sleep, shortly after the patient has retired, and typically last an hour or two or three. Many months may intervene between paroxysms, as is also true in tic. The migraine attack is a severe headache lasting many hours or a few days. During the attack the pain is unremitting. As a rule, the attacks occur with fair frequency—every few days or weeks, but the remissions may be very protracted—months long.

Of great value in differential diagnosis is the relation of the pain to external stimuli or to acts requiring contraction of the muscles of the face, jaw, tongue or throat. A cold breeze blowing against the face, washing, shaving will release or aggravate an attack of trigeminal neuralgia. So, too, will talking, laughing, biting, swallowing, coughing, spitting, sneezing, blowing the nose, brushing the teeth, running the tongue along the dental ridge. Similarly, yawning will precipitate glossopharyngeal neuralgia. Always in *tic douloureux* several of these acts will induce the pain. But they are ineffective in the continuing post-herpetic neuralgias of the fifth or seventh nerves, migraine, and histaminic cephalalgia. Nor do they operate characteristically in hysterical facial pain. Closely related are the trigger zones almost always demonstrable in the organic neuralgias occurring in and about the face. These are small areas stimulation of which fires off the pain. The absence of any such zone casts serious doubt on the diagnosis of neuralgia. In fifth nerve neuralgia these

zones are found most often at the corner of the nose, in the upper or lower lip, or somewhere along the alveolar ridge. In ninth nerve neuralgia the trigger point is at the base of the tongue on one side or in the faucial tonsil. In geniculate neuralgia a trigger zone has been noted deep in the posterior wall of the external auditory canal lateral to the drum.

The patient's general behaviour during the attack of pain has valuable differential diagnostic weight. The quick misery of the true tic patient coming in mid-sentence as he talks or appearing suddenly when he is asked to bite down hard, his screwed-up face, his involuntary clutch at or towards it, the swift tension that appears in feature and body as he braces himself to meet the pain are genuine. There is a different quality in the reaction of the hysterical sufferer, whose unpainful countenance excites no sympathy.

Specific features typical or highly suggestive of known clinical syndromes will aid in classification of the pain. A bleary, congested eye and a profuse, watery rhinorrhea occur on the side of the pain in Horton's cephalalgia. Here, too, may be a taut superficial temporal or carotid artery, compression of which may momentarily dull the pain. These features are absent in tic douloureux. Nor in tic is there a hereditary predisposition, as occurs in migraine; nor the scotomata or vomiting of migraine, nor the scars of an old herpes, as in ophthalmic zoster.

In occasional cases associated neurological findings are invaluable. Anesthesia of the face, paralysis of the muscles of mastication, loss of the corneal reflex, papilledema may point to a tumor of the gasserian ganglion, primary or metastatic, as the causative lesion. I have seen violent pain in the face as the leading symptom of syphilitic basilar meningitis. In this case there was neurological evidence of impaired conductivity in the fifth nerve, accompanied by a homolateral sixth nerve weakness and strongly positive serology. The lightning pains of tabes dorsalis may occur exclusively or almost exclusively in the area of the trigeminus. In such cases the diagnosis is established by eliciting the neurological evidence of tabes. Certainly in every case of persisting pain in the face a complete neurological survey is necessary.

The general problem of treatment of pain in and about the face is a many-sided one, calling for the exercise of diverse skills. In the individual case treatment naturally hinges upon the cause. In this discussion I am concerned chiefly with the neurosurgical side.



The neurosurgical treatment of pain about the face is either specific or palliative. In the former the lesion causing the pain is eradicated by a surgical procedure, such as removal of a tumor of the gasserian ganglion or of the cerebellopontine angle. Such cases are rare. Much more often the treatment is palliative. This involves interruption of the route of the pain impulse to the sensorium. An accurate diagnosis of the pathway to the sensorium is necessary. It does no good to interrupt the trigeminal nerve if the pain is travelling over the ninth nerve.

The sensory path may be divided at different sites—peripheral nerve branch, ganglionic or spinal root, central pathway in the medulla. Preferably it should be divided at a point where regeneration of nerve fibers is impossible. This effects permanent relief.

In practice the following sensory systems must be considered: fifth, seventh, ninth and tenth cranial nerves, small occipital and great auricular nerves, and the sympathetic.

The trigeminal system is best interrupted by division of the sensory root of the gasserian ganglion. Surgical division of peripheral branches is unwise. However, alcoholic block of peripheral trunks is desirable in some cases, although it affords only temporary relief. Tractotomy, or division of the descending root of the trigeminus in the medulla, is surgically possible but is of uncertain effectiveness, dangerous, and not to be recommended.

The nerve of Wrisberg, the sensory component of the seventh cranial nerve, has been successfully divided intracranially for geniculate neuralgia.

Alcohol injection of the glossopharyngeal nerve in the neck or intracranially is impossible. For abolition of pain coursing over this nerve, the ganglionic root must be divided within the posterior fossa.

Division of the vagus for rare cases of otitic neuralgia with implication of Arnold's nerve is surgically possible but would be injudicious.

Pain in the auricle or at the angle of the jaw might be relieved by division of the great auricular nerve at the posterior edge of the sternocleidomastoid muscle. Since the small occipital nerve sends fibers to the cranial surface of the auricle it, too, might need to be divided at this site. Regeneration of fibers will occur and the pain might return. However, posterior spinal rhizotomy or division of the spinothalamic tract in the medulla for pain travelling over these nerves would usually be unwise.



Interruption of the cervical sympathetic for elimination of pain about the face has been generally unsuccessful, and is not to be urged.

Whether or not the patient submits to a neurosurgical procedure depends entirely upon the severity of the pain. There is nothing life-saving about division of any of these pathways. However, in any case of excruciating, incapacitating pain interruption of the appropriate path will contribute to the comfort and welfare of the patient, and can be accomplished at small risk and with little important functional loss.

608 HUME MANSUR BUILDING.

## XXXVII

### HEMANGIOMA OF THE EAR

#### A NEW METHOD FOR THE CONTROL OF HEMORRHAGE

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When profuse and unexplained hemorrhage occurs from the ear canal, it practically always indicates some vascular anomaly within the mastoid process or the middle ear or both, which has developed to the point where the covering of the vessels is no longer able to withstand the increasing tension.

The following two patients illustrate by their operative findings how futile it is to "dilly-dally" with various types of treatment with the expectation that the condition will subside without radical surgery. Even with modern otological surgery, the problem has not been easy to manage because of the impossibility of ligating blood vessels in this area. New methods of hemorrhage control have been used successfully in each of these two cases.

CASE 1. Miss A., a 59-year-old woman, was admitted to the hospital because of sudden and profuse bleeding from her left ear canal which required tight packing to control. She had known for 15 years that she had a bleeding mass in her left external auditory canal for which she had received radium treatments and actual cautery with intervals of complete relief. She had lost a considerable amount of blood, although her hemoglobin was 77 per cent and she had 3,720,000 red blood cells. There was a marked swelling with an enormous dilatation of the superficial blood vessels over her mastoid process. The swelling did not pulsate, but it pushed the ear forward similar to a subperiosteal suppuration.

When the usual mastoid incision was carried down through the soft tissues, there was free bleeding which was easily controlled. During the removal of the bony cortex of the mastoid process bleeding became so extensive when the antrum was opened that tight packing with marine sponges was required. Removal of these sponges soon disclosed the fact that immediate and permanent packing would be necessary to prevent the patient from becoming exsanguinated.

This bleeding also extended out along the anterior surface of the bony facial ridge beneath the periosteum, and several marine sponges were inserted in this area to control the escaping blood.

The question then arose as to the source of the bleeding, and since it appeared improbable that this could be accurately determined without risk to the patient, these sponges were left in place and the wound was tightly sutured. This controlled the bleeding, and about a week later some of the sponges were removed each day until finally all were removed without any recurrence of bleeding.

During her convalescence there was considerable secondary wound infection with a foul-smelling discharge, but at no time did the patient react unfavorably. Transfusion was not necessary.

The pathologist reported an irregular growth of small, solid nests of cells and numerous cavernous vascular sinuses, most of them empty. Many of them were lined by flattened endothelium. In the interstitial tissues little groups of cells with a nevoid appearance were encountered. The nuclei were rather small and pyknotic in character. They were embedded in the walls of these cavernous sinuses. There was some hyalinization of the interstitial connective tissue and along one edge there were some squamous epiderm showing hyperkeratinization and no pegs to speak of, suggesting an invagination of squamous epithelium with the production of a dermoid. The diagnosis was hemangioma of the ear.

CASE 2. About a month later, Mr. B., a 46-year-old farmer, came to me with the complaint of bleeding from his right ear. He was reluctant to discuss his condition completely, but seemed anxious and worried, and finally I learned that this ear had drained intermittently for 21 years, and that he had had polypi removed from the ear canal several times during that interval. The last otologist to see him advised him to have a mastoidectomy and refused to remove the polypi on account of the danger of hemorrhage. He had already lost his hearing in this ear and had a twitching on the right side of his face in the area supplied by the facial nerve. He was inclined to be a bit overweight and had a florid complexion.

Examination of the ear revealed a blue, smooth, nonpulsating mass completely filling the ear canal. It seemed to be attached to the posterior wall, but no effort was made to determine this fact because of the danger of bleeding. There was dried blood still in the ear canal. The skin around the external auditory meatus had a thick scarlike appearance. The small superficial vessels over the mastoid

process were engorged, but there was no swelling or tenderness. A roentgen study revealed a chronic infection of the mastoid process with a thickened cortex, which was in keeping with the history of ear infection of 21 years' duration. His blood pressure was 160/90.

A mastoidectomy was recommended and performed the following day under general anesthesia. While being anesthetized the patient started to bleed freely from his ear canal. This was controlled without difficulty by the use of marine sponge packs.

The postauricular soft tissues were normal and upon incision there was no exceptional bleeding, although the small arteries spurted considerably, apparently on account of his hypertension. The periosteum was elevated easily and the cortex was smooth, hard, irregular and very dry. The sigmoid sinus was exposed over an area of one square centimeter. It was superficial and anterior. Lying posterior to the antrum and extending back and upward was a group of infected cells with only a moderate breaking down of the trabeculae. This extended forward into the antrum.

The mastoid gutter was cleaned out from the infected tip cells up into the antrum and after this part of the operation was completed, the bony covering of the fallopian canal was exposed throughout its course, and could be plainly seen as a white eburneous ridge running along the posterior surface of the exposed anterior wall. The facial ridge was lowered over the antrum and the posterior border of the flap, when exposed, was engorged with a vascular plexus which seemed to be principally venous. When the antrum was opened, very free nonpulsating bleeding took place which arose anteriorly from the vascular tumor within the ear canal.

In order to control the bleeding from the antrum, marine sponges were tightly packed into the cavity, which were left in place for five minutes. When they were removed, the bleeding recurred as profusely as before. Obviously, it was apparent that some sort of a permanent packing was desirable. Therefore, the patient's own tissue offered the best means of doing this.

Heretofore, I have used a strip of temporal muscle, but this cavity was so deep and the temporal muscle so short, that I elected to use a segment from the lower end of the soft tissue flap. I divided this flap, starting from the lower end of the incision beneath the tip and extending upward to a point over the antrum. When this strip of periosteum and soft tissue with tags of raw muscle was inserted into the freely bleeding antrum cavity, the hemorrhage was promptly controlled by moderate finger pressure upon the outer skin.

This flap also had an advantage over the temporal flap because there was no tension. It also retained a good blood supply, and, being principally composed of periosteum on its surface, it resumed its former habitat when placed adjacent to the bone. Finger pressure was applied while the wound was sutured in the usual manner with mattress sutures, and two small marine sponges were applied for compression over this flap.

For four days after the operation, the patient seemed all right; then suddenly he had a chill with a temperature rise to  $104^{\circ}$  F. The question then arose in my mind, did this patient have a thrombophlebitis of his exposed sigmoid sinus, or was there a suppurative extension into the thrombus which was caused by blocking this opened vascular bed within the infected mastoid process? The latter seemed more probable.

The patient looked very sick and was quite anxious about himself, and I was prepared for a disaster. At this time I noticed a marked swelling of his right parotid gland, and when I tried to look into his mouth, he was unable to get his jaws apart. The patient then advised me that whenever polypi were removed from this ear canal he had had this same dislocation of his jaw with swelling of his parotid gland. Fifteen months before, he had had a bilateral parotitis, and at that time he was confined to bed and was fairly sick. He had never had mumps before in his life, and had been exposed to them at that time in his immediate family.

Roentgen films of his mandibular articulations revealed an interesting phenomenon on the right side. The condylar process on the right side of the mandible was displaced upward and forward in both open and closed positions. There was no evident erosion of the bone or absorption of the cartilage. The condylar process had been pushed outward and forward and downward probably by some inflammatory process near the posterior portion of the joint. This peculiar and accidental phenomenon was not only unexpected but remains unexplainable because of the facts that he had every normal tooth in his head and had always had normal occlusion. He had never had an injury to his jaw.

During his convalescence he confided to me that he had been told that he had a malignant lesion in this ear and that it would be fatal. He also admitted that he had withheld from me the complete history and that he had lost over a quart of blood from his ear canal during the hemorrhage seven days prior to his visit to me. Also, he had had numerous x-ray treatments upon this lesion within the ear

canal. He stated that this peculiar twitching of his face only came on during the past two and one half years and was always worse when his ear bothered him most. While he was concerned about the hemorrhage, it did not bother him much because he stated that he actually felt better after this loss of blood. He had a heat stroke and was unable to work in the summer months but felt fine in the winter time and could stand any amount of cold.

Although he had given no particular regard to his loss of hearing and had not anticipated any great improvement from this operation, the patient told me that his greatest satisfaction was the unexpected but complete restoration of hearing in the operated ear. This I considered of no particular consequence as I had been more concerned about a possible recurrence of hemorrhage. Fortunately, he has had no loss of blood since his operation, and healing has been complete and uneventful.

To summarize, this man had the following conditions: (1) hypertension; (2) an arteriovenous lesion in his mastoid process with erosion into the external auditory canal; (3) low-grade x-ray burn about the skin of the external auditory meatus; (4) a nonsuppurative parotitis; (5) dislocation of his right mandibular joint; (6) chronic suppurative mastoiditis of 21 years' duration; (7) partial facial paralysis due to erosion into the fallopian canal; (8) loss of hearing.

*Comparison of the Two Cases.* These two patients had the same type of lesion with a very similar history. It was not so much a diagnostic problem, but immediately became a matter of saving the life of the patient by the control of the hemorrhage. In one patient, during the course of the operation, it became necessary to immediately control the bleeding. Since marine sponges were used as a routine measure in the operation, they were immediately applied and as they controlled the bleeding, they were left in place. There was the usual mild and nontoxic suppuration and secretion within the meshes of the sponges, which in time broke down and were expelled. The normal processes of healing of the open venous plexus completely and permanently obliterated this vascular lesion and the ultimate result has been quite satisfactory.

Due principally to the facts that the bleeding in the second patient was under control until the antrum was opened and the area was small, the viable tissue flap was used. In this case, the muscle flap had advantages over the marine sponge in that it was viable tissue, it more rapidly promoted the processes of coagulation and would permanently remain in place. Wound healing was permanent.

without secondary infection. Having had a previous similar experience with this flap, I felt reasonably safe in the use of the viable tissue.<sup>1</sup>

Another advantage in this second case was the large postauricular flap<sup>2</sup> which I use routinely in all mastoidectomies. Had it not been for this wide postauricular incision, enough viable tissue would not have been available for this use.

1617 PROFESSIONAL BUILDING.

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XXXVIII

CLINICAL OBSERVATIONS ON THE PALATINE TONSIL  
IN THE AGED

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Although reports on the presence, state and surroundings of tonsils in the aged are frequently found, for the most part only a few words are dedicated to this subject. Usually such reports are scattered in the histories of patients with many ailments and in surveys of tonsillar conditions in general. The lack of a systematical study of this question is clearly felt, especially so where an early involution of these organs is taken for granted although there is sufficient evidence in the literature to show that these prominent parts of the lymphatic system hold their ground far into advanced age. It is the purpose of this study to approach this question clinically as a continuation of two previous reports<sup>9, 10</sup> on the same subject.

Data on tonsils may be obtained by one of three methods: (1) examination of organs from cadavers; (2) examination of operative material; and (3) clinical observation. While one method will yield data unobtainable by the other two, the results of all three should be considered to obtain an integrated picture.

Krumbhaar<sup>12</sup> favors the postmortem examination; it is his belief that there is less possibility of fallacious deductions. Ehrich<sup>5</sup> emphasizes the rapid disintegration of the lymphatic tissue in the cadaver. Since nutritional changes in the last days of lethal disease cause rapid depletion, any observation of the size and volume of a tonsil taken from the cadaver may not be considered reliable. Mathies,<sup>14</sup> although working on material from autopsies, conceded that data regarding percentage could be collected only by observation of healthy individuals of every age group. However, a reliable histological picture can be obtained only by examination of operative material; fixation immediately after removal is of paramount importance in this procedure. Such material gives little information, on the other hand, concern-

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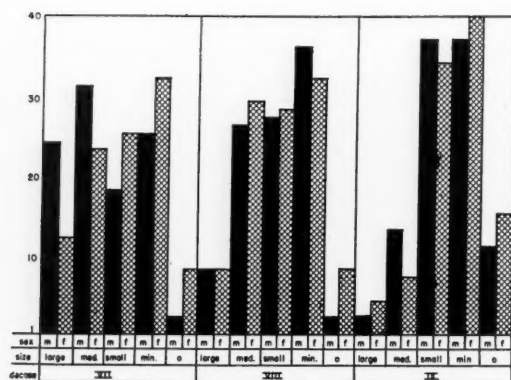


Table 1—Size of Tonsils.

ing retrotonsillar conditions, whereas in a cadaver, as much of the surrounding tissues as is desirable may be removed with the tonsil.

One hundred patients with and without tonsillar complaints, 50 males and 50 females in each of the seventh, eighth, and ninth decades were examined. In addition to these 300, 9 additional persons between the ages of 90 and 103 were examined. These patients were seen on the services of the Boston Dispensary, the Long Island Hospital of the City of Boston, the Massachusetts General Hospital, the Home for Aged Couples and the Home for Aged Colored Women in Boston.

The observations were conducted on a purely clinical basis. After obtaining as complete a history as was possible regarding pharyngeal conditions, the records of these institutions were reviewed to ascertain the possible bearing of tonsillar changes on other parts of the organism. Each person was examined only once except those with acute tonsillar or peritonsillar inflammation. These patients were followed until recovery.

*Size.* With advancing age, a steady decline in the size will be noted in Table 1 by a decrease in the length of the columns for large and medium and an increase in those for small and minimal size. In Table 2, the figures obtained for the male and female groups are added for each decade. From this table it is seen that the size continues to decrease as the number of years increases. Curve 5 of this

table represents completely empty fossae; in seven patients in their eighties, previous tonsillectomy had been performed. Disregarding these operative cases the broken line represents the absence of the organ. Curve 5 also demonstrates the sudden appearance of a comparatively high figure for total absence of any tissue in the fossa in the ninth decade, whereas in earlier years a completely empty fossa is rarely encountered.

In 9 patients over 90 years of age only 4 empty fossae were seen; thus in this age group there was complete disappearance of the tonsils in 11 per cent. Two centenarians were included; one, a man 101 years old who had on the right side a small yellow elevation in the center of the fossa; while on the left side there were flat masses with several yellow cysts filling the upper two-thirds of the fossa; two, a woman, 103 years of age, who had a flat mass in the lower one third of the fossa on the right side, while on the left side no vestiges of the organ could be discovered. This would indicate that in these persons over 100 years of age, only 1 of 4 tonsils disappeared completely.

While the mass of tonsillar tissue decreases steadily after the seventh decade, complete disappearance does not become eminent before the ninth decade. On the other hand even in the centenarians the empty fossa is not a typical finding.

*Location.* How much of the area of the fossa is covered by the tonsil and where the remnants are located is of minor clinical consequence. However, data regarding the disappearance of the tonsil may be obtained from these facts. Adding the figures for both sexes, the number of forms protruding beyond the level of the arches remains remarkably constant for the seventh, eighth, and ninth decades: 13, 11, and 11 respectively. Forms filling the entire fossa up to its rim numbered 44 and 43 through the seventh and eighth decades while they dropped to one third of this in the ninth decade.

The location of these forms is characteristic when the fossa is only partly occupied. A tendency to retract from the arches may be seen in the frequent occurrence of narrow vertical ridges of tonsillar tissue along the deep longitudinal axis of the fossa (67 cases) as contrasted to the adhesion of patches to some small area of the arches (17 cases). Completely isolated patches scattered across the entire fossa were encountered 22 times. With advancing age it was remarkable that the tendency was to retreat against the lower parts of the fossa where tonsillar tissue was noticed twice as frequently as in the upper half alone. The presence of central location in but 82 instances demonstrates the tendency to retreat in the direction of the two extremities

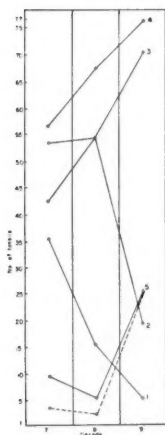


Table 2—Size of Tonsils—1, large; 2, medium; 3, small; 4, minimal; 5, empty fossa. (Broken line, after deduction of the cases with previous tonsillectomy.)

of the fossa. The relatively infrequent picture of small, scattered, isolated patches probably indicates that whenever this stage is reached it will be rapidly followed by complete resorption. This supposition is supported by the ratio between the figures for scattered forms and complete absence: 1.1 to 1 in the seventh decade and 1.09 to 1 in the eighth decade, whereas in the ninth decade it is 1 to 3, showing the increase of this process in the last age group.

*Color.* A pale color may be assumed to be the sign of a higher grade of cicatrization and a dark red of acute or subacute inflammation. In fact, the latter finding was encountered frequently in cases which are discussed under the heading of acute inflammatory conditions. No characteristic color could be found for the different age groups.

*Aspect of Surface.* With all the well-known varieties, such as smooth, ragged, beehive, cauliflower, the surface aspect is of interest as indicative of the state of involution. Flat plaques, and weblike linings of the bottom of the fossa were noted. Importance must be attached to the cryptal orifices. They are represented by many forms from shallow depressions to deep craters. The deep funnel appears as the typical result of the involutionary process of eversion.

*Cryptal Contents.* With the first sign of involution of the crypts (opening and eversion), their capacity to retain their normal inclusion (dry detritus) decreases rapidly. No positive finding was noted in those over 90 years of age. On the other hand, the pathological content of liquid pus appeared with astonishing frequency even at the age when dry detritus disappeared rapidly.

Two cases of special interest in this regard were seen. In a man 63 years of age, an acute inflammation of the tonsils was noted; slight expression evacuated seemingly endless quantities of pus through the cryptal orifices. This was repeated after five days. Although he had been treated for nine years for obesity, diabetes, and poor circulation in the legs, he never had any pharyngeal or tonsillar complaints. Another man, 65 years of age, had so much tonsillar tissue that it completely filled the fossae. The tonsils and their surroundings appeared slightly inflamed. Here again, expression resulted in a flow of an endless quantity of pus on both sides from a single opening near the upper pole. This man had been treated for obesity, phlebitis, and ulcers of the leg, but had never had any pharyngeal or tonsillar complaints.

*Involutionary Forms.* There are three typical involutionary forms. Retreat of the tonsillar mass into the longitudinal axis of the fossa produces a longitudinal ridge. This may be formed entirely by tonsillar tissue but frequently a sharp ligamentous ridge is evident with a rosary-like row of small beads of tonsillar tissue perched on its edge. Another typical form is a large drop which starts with a pedicle-like portion from the center and enlarges downwards, frequently reaching below the lower pole of the fossa. The tendency of the regressing tonsil to liberate first the upper part of the niche is indicated in this manner. A small crater surrounding a last cryptal opening is sometimes seen, preceding complete disappearance (compare the findings in Reference 10, pp. 433-434).

*The Tonsillar Fossa.* This is untouched by the involuntary process going on within its arches. Tabulation of the data in the 44 cases in which a completely empty fossa was observed showed the following: completely smooth arches were encountered in only 2 patients who had had previous tonsillectomies; otherwise the fossae were small, spacious, large, or very large, and generally well developed. In one woman, 103 years of age, the fossae were well formed on both sides; one was completely empty and the other contained a small remnant. One man, 101 years of age, had two deep, well-developed fossae. Sometimes the above-mentioned ligamentous ridge protruded sharply

in its course from the upper to the lower pole with all vestiges of tonsillar tissue gone from its edge. In one case a single arch formed the upper two thirds which in the lower one third opened into the customary two branches. The arches showed no tendency to retreat in the wake of the regressing tonsil or to close up after its disappearance. In the 26 instances in which closed arches were seen, the definite presence of a tonsil behind them was noted and was probably the result of a concretion after a peritonsillar attack.

Since no histological examinations were made, only surface cysts were observed as indicative of degeneration. Their relative infrequency does not justify their consideration as a characteristic involutory finding. They were seen in 16 persons; in 12 they were unilateral, in 4 bilateral; in 7 a single cyst was noted; in 9 several were found. In the 101-year-old man, a single cyst in the center was seen on the right side; on the left side several scattered ones were distributed over the entire surface of the fossa. In all cases the color was the typical transparent yellow.

One patient presented a small angioma on the left anterior arch; another a pedunculated mass in the center of the tonsil. No additional benign or other growths were found.

Although these patients were examined painstakingly for the presence of enlarged lymph nodes, only 4 instances of enlargement were noted; in 3, it was unilateral, and in 1, bilateral. The oldest patient to exhibit a unilateral retroangular node was an 84-year-old woman: she had only a minimal tonsillar remnant on the same side. In one patient with a unilateral lymphadenitis, an acute tonsillitis was also noted.

Eight patients were found to have soft, enlarged submandibular salivary glands; with one exception, the involvement was bilateral. These swellings never caused any complaints.

*Acute Tonsillitis and Peritonsillitis.* These conditions were noted in only eight of 309 patients. Of these 8, complaints of this nature were reported in the history only three times over a long period of time. One was a woman 72 years old who had many peritonsillar attacks, the last one 50 years ago; another was a woman 74 years old who had had many peritonsillar attacks between the ages of 16 and 22; a man 88 years old had had his tonsils incised several times in childhood because of peritonsillitis. In the first and second patients, the tonsils were of medium size; the third had minimal tonsillar tissue on both sides amidst extensive cicatrization.

The 5 patients with acute tonsillitis showed the following: one man, aged 61, was seen who had acute follicular tonsillitis with enlarged retromandibular nodes; this was his first attack and it lasted one week. In one man, 63 years old, who had had obesity and diabetes, both tonsils were dark red and an endless quantity of pus exuded from the cryptal openings; his condition did not change during the five days' observation. One man, aged 64, had many pharyngeal complaints but had never before had tonsillitis; redness and swelling of the tonsils and their surroundings were observed over a period of eight days. A woman, aged 68, had intermittent tonsillar inflammation since five years of age; pain had started two days before she was seen; on the left side a pea-sized tonsillar remnant was noted which was swollen and covered with follicles; the arches were swollen. One man, aged 71, had had a tonsillectomy ten years previously; on both sides there were large regenerates; the left regenerate was red, inflamed, and swollen into one mass with the arches and a large quantity of pus exuded from the cryptal openings; after three days all signs of inflammation had subsided.

*Tonsillectomy.* In two cases, the operation had been performed at the age of 61 years; the longest interval since operation was 60 years. Indications for tonsillectomy included local conditions, aural complaints and arthritis. The tonsillar fossae were empty in 5 cases; scanty regeneration was present in 3 and extensive in 7 cases. The influence of the operation was often beneficial even with local regeneration. The tonsillar condition was completely relieved in 7 instances, the aural condition was relieved in one, and unchanged in one; in one patient otitis developed many years later. In one instance the arthritis was improved and in 4, it remained unchanged. Of interest is the age at which the operation was performed; the frequency of operation was the greatest in those at and beyond middle age.

*Unilaterality and Bilaterality.* The size of the tonsils was often found considerably different on the two sides. It can be presumed that this difference will be present more frequently with an increase in age. It has no significance other than that the two organs reached a different point on their way to involution. Pathological content could be recovered as often unilaterally as bilaterally between the ages of 71 and 90. It is notable that bilateral involvement occurred twice as often in the seventh decade as unilateral. Following tonsillectomies the local condition, absence or regeneration, was the same on both sides even when many years had elapsed since the operation.

## COMMENT

The role and the fate of the tonsils in the aging organism differ from that of many other organs. According to Berens,<sup>2</sup> who discussed the aging process in the eye, there seems to be little question that faulty circulation and degeneration (the result of vascular changes) are responsible for many of the visual disturbances of adults which are often attributed to age. Many of the so-called old age processes in the eyes are caused directly or indirectly by infection. The tonsil has to cope with infections during its entire existence. This may be the cause of the fact that it lives a remarkably independent life amid the degenerative and infectious processes occurring in old age. Stieglitz,<sup>18</sup> quotes Osler's remark: "A man is as old as his arteries", and adds: "and as his vision or his imagination." But a person is certainly not as old as his tonsils. This organ would comparatively rarely reveal the age of its bearer.

Total involution means total disappearance of tonsillar substance from the fossa, which in these cases is lined with an unbroken and smooth mucous membrane. Only in the ninth decade does this condition occur with any frequency. Forms of necrotic tonsillitis resulting in a similar condition have been described, for example, so-called lymphocytic angina; usually a complete regeneration follows in these cases. Regeneration followed most of the tonsillectomies reported by our patients. Even in the oldest patients a totally empty fossa is by far not the most frequent finding and thus it must be concluded that the tonsil generally does not reach total involution during lifetime. According to Krumbhaar,<sup>12</sup> the fallacy of the statement that normal palatine tonsils should disappear in the third decade is recognized. As confirmed by postmortem examination, they may remain throughout life and some think they remain at their fullest development until well after puberty.

In 1913, on the basis of anatomical studies, Hett<sup>7</sup> stated that by middle age there is a flat or hollow space between the pillars consisting mainly of fibrous tissue and usually, although not invariably, a few crypts and some remnant of the supratonsillar fossa remains. But, in 1933, Wessel<sup>10</sup> found increasing volume up to puberty and then constancy until the middle of the fourth decade with a steep decline following in the fifth and another in the seventh decade. He called the first decline a physiological, the second, a senescent involution. Hieronimus,<sup>8</sup> in the same year and at the same institute, examined the tonsils of 100 cadavers taking the area of the largest cross section of the organ as the basis of study. He found full develop-



ment far beyond puberty and fixed the first period of steep decline in the curves at the fourth decade and the second at the seventh, as did Wessel.

The findings of this study on patients 61 years and over contradicts those deductions of Hieronimus.<sup>8</sup> In the age groups between 70 and 90, he found that 100 per cent of the tonsils were small and in those between 38 and 70, 27 per cent. This study shows that between the ages of 70 and 90, 5.5 per cent of the tonsils were large and 19 per cent were of medium size. This difference may be accounted for by the fact that Hieronimus examined the organ in cadavers while this study is based on clinical observation. Such a difference may substantiate the advantage of the last-mentioned method at least in the evaluation of the size of the organ.

Mathies,<sup>14</sup> in 1935, emphasized the necessity of considering only living and healthy persons; on the basis of his study of 500 autopsies, he found that between the ages of 65 and 90 the percentage for large, medium and small tonsils was respectively 19.4, 27.5, and 53.1. As he used the terms large, medium, and small with different definitions for the different age groups, it is difficult to correlate his findings and those of other workers.

The plateau in the curve of Hieronimus<sup>8</sup> corresponding to the period from 45 to 65, between two periods of decline, shows a slight elevation around the sixties. Clinically one is impressed by the fact that in the sixth decade at the beginning of senescence or the threshold of "second childhood", there may be even a slight temporary increase of volume which would correspond to the increase generally noted in the first decade. Definite data regarding this phenomenon could be attained only by observations repeated at frequent intervals in the same individual over a sufficiently long period of time around this age.

There is also a close correlation between the location and what might be termed the typical involutinal forms. The picture caused by retreat of the tonsillar masses from the pillars leaving them often free at a comparatively early age is in accord with the findings of Mathies.<sup>14</sup> He found that in senescence those tonsils of the large type were long in shape, in a good state of development, and filled out the floor of the fossa. The typical descent resulting in the "drop-like" form does not substantiate the observation of Minear, Arey and Milton<sup>15</sup> in that the crypt system of the inferior half of the tonsil is the first to degenerate. Tonsils of "drop" form, as in fact every other remnant of the organ, are always tissue blocks disposed around



crypts.<sup>10</sup> This means that in the majority of the cases the last crypts to be observed will be those at the lower pole.

The longitudinal ridge is frequently built upon a central, sharp ligamentous fold which may be present even after the tonsillar tissue which was carried on the edge of the fold has disappeared. Disintegration is present when small bead-like disconnected remnants similar to a rosary are seen, covering the ridge. As the plica intratonsillaris of embryonic life is a structure of horizontal course, dividing the organ in an upper and lower half, it is interesting that in involution a similar structure appears but turned in its course 90° as compared to its embryonic counterpart.

Large and shallow cryptal orifices correspond to the process of eversion as previously described in detail.<sup>10</sup> Scarcity of cryptal material is a frequent note in histological descriptions of tonsils in old age. This is a purely mechanical phenomenon as shallow crypts with wide openings are unable to retain any content. Accordingly, rapid eversion, breaking up of the crypts with advancing regression, makes the quantity of included material less and less. It is obvious that this has no bearing on the formation of pus in inflammatory processes, which will be found in tonsils of any age and of any evolutionary stage. In patients over 90 years of age, no material was obtained by expression.

Included material was found generally in the same quantity on both sides, showing an equal grade of regression. This parallelism started characteristically with the seventh decade.<sup>10</sup> Berggren and Hellman<sup>3</sup> found the same degree of involution on both sides in the majority of their cases.

The aspect of the tonsillar fossa is seemingly completely independent from the state of the tissues within its boundaries. Complete disappearance of the arches and retraction into the pharyngeal wall commonly occurs after tonsillectomy even with carefully preserved pillars. But when a tonsil disappears by involution rather than operation, such changes do not occur. This may be explained by the disposition of the blood supply of the arches which is entirely independent from that of the tonsils (Brouca<sup>1</sup>). Inevitable disturbance of the blood supply at the operation may cause atrophy of the pillars whereas no similar changes occur around the regressing tonsil.

The incidence of cysts was no greater in this group than in younger ones; yet it must be borne in mind that the present findings deal only with surface structures. In the previous study<sup>10</sup> cysts were

found to occur three times more frequently in disorganized than in fully-developed tonsils.

The clinical consequences of the tonsillar involution should be discussed in two groups: local and general implications. The aging tonsils do not play any decisive role in the processes of their immediate surroundings, but even the smallest remnants remain an important factor in producing general changes.<sup>9</sup> According to Krumbhaar<sup>12</sup> it can be assumed that the efficient response of the tonsils to infection at any age and the fewer local infections in older life would indicate that the two involutionary periods in the fourth and seventh decades represent lessened need rather than obligatory atrophy of old age. Perhaps the most striking sign of lessened influence in the region is the almost complete absence of the enlarged retroangular lymph node so common in younger people. No relation can be found between the tonsil and the enlarged submandibular salivary glands. Four of the eight patients with such a finding were negroes; this is noteworthy in view of the fact that only six of all our patients were colored.

Peritonsillar inflammations were reported by a few individuals, occurring as long as 50 years ago in one case. These outbreaks generally occurred in their youth. On rare occasions acute tonsillitis was seen. The attack may be the first one, even in the seventh decade; it may involve well-developed or involuted tonsils as well as small remnants after regression, or regenerates after tonsillectomy. This can be easily explained since we know that the difference between well-developed and involuted tonsils is only a quantitative one, both presenting identical structure,<sup>10</sup> and that every regenerate within the tonsillar fossa histologically assumes the typical tonsillar composition.

In only a very few of the 15 histories with a previous tonsillectomy was it reported that the operation had been performed in early youth. For the sake of comparison it was noted that in a group of 134 healthy boys between the ages of 10 and 17 of presumably the same social strata, seen at the Boston Dispensary in May, 1942, (the so-called "caddy-draft") 72 per cent had had their tonsils removed. Gallagher<sup>6</sup> reported that a tonsillectomy had been performed in about 80 per cent of a group of 910 students of Phillips Academy, Andover, Mass., ranging from 13 to 19 years of age.

It is assumed sometimes that when the operation is performed in later years, regeneration is less frequent. This can not be substantiated by the figures obtained in this study, since regeneration occurred

after tonsillectomy had been performed in the seventh decade. It is possible that the above discussed second period of increased tonsillar activity may have some bearing on the frequency of regeneration in these age groups.

Besides local and aural changes, arthritis seemed to be a frequent indication for operation even many years ago. The results as to these manifestations of focal infection were moderate while local complaints were for the most part completely and definitely relieved.

From these observations as well as from the apparent lack of reports on operative accidents it can be concluded that there is no reason why the advantages of a tonsillectomy should be denied individuals of advanced age. Usually opponents of this view formulate their opinions in generalities. However, in the series of 11,088 cases of the Mayo Clinic, reported by Wilkinson,<sup>20</sup> on which tonsillectomy was performed, 355 patients between the ages of 60 and 79 are included. Brooks has been quoted by Babbitt<sup>1</sup> as saying that more surgery in old patients could be safely attempted when neglected or acute cases are present, and these patients will be more ready today for any justifiable operation than they were ten years ago.

As to general conditions noted in these patients after tonsillectomy, obesity and psychoneurosis were outstanding. A connection between tonsillar conditions and changes in the upper airways is frequent. The interrelation between these changes and the above-mentioned two general conditions was discussed in a previous paper.<sup>11</sup>

Proper evaluation of all these conditions in their inter-relations is impeded by the difficulty of taking a true history in old people. Frequently reports concerning previous tonsillar complaints are lacking, although it is known that such episodes are universally experienced in early years. Moore<sup>16</sup> said: "—When those diseases which ordinarily occur in the earlier decades of life make their appearance after the age of 50, the symptoms and signs are frequently altered or so different as to cause many commissive and omissive errors in diagnosis." It is common in youth to regard diseases as caused by tonsillar foci and this possibility should be given more consideration once the misconception that the tonsils disappear round the middle age is eliminated.

Apart from the many cases of difficult mental approach or outright psychoneurosis, other factors have to be considered which make history-taking in the aged a difficult task. Rapaport<sup>17</sup> mentioned that patients "forget" to give what is most pertinent information or unwittingly give false replies to questions, and he concludes that the

processes of perception, memory and forgetting are closely connected with emotional feelings.

The picture becomes more and more complex with advancing age. It would be erroneous to presume that evaluation of a person's status is simpler in the regressive phase of his life. This concerns the tonsillar problems, too. The role of these organs in older age groups needs to be considered carefully once their presence throughout senescence is generally recognized.

Lee,<sup>13</sup> in speaking of the elderly, said that certain people develop conditions or diseases, the explanation of which is that it isn't wear and tear; it is just rust. Quite a few of these difficulties may be ascribed to the tonsils. Preventive geriatrics will gain when more attention is given to these organs at the threshold of the regressive years.

#### SUMMARY

Clinical examination of tonsils was performed in 309 patients, 50 men and 50 women in each of the seventh, eighth, and ninth decade of life, and an additional 9 patients whose ages ranged from 90 to 103.

A steady decline in the size of the tonsils in these years was noted, but complete disappearance is rare; in fact, it was less frequent than the presence of large, fully-developed tonsils. Characteristic involutional forms are the vertical narrow ridge, the large drop in the lower pole of the fossa where the greatest part of the remnants are found, and the small crater surrounding the last crypt.

The tonsillar fossa is not included in the involutionary process. It remains a more or less spacious niche with its arches even more conspicuous when empty.

Local inflammations, tonsillar and peritonsillar, are infrequent and take the same course as in any other age group. The attack may be the first one and may involve small remnants or regenerates after tonsillectomy. Fifteen patients with previous removal of the tonsils gave uncomplicated operative histories; the local results were excellent although the improvement in their general condition was dubious. No greater operative risk was present in the aged than in the young.

Around the sixth decade there is a period of high tonsillar activity; regression seems to cease with even a slight possible temporary enlargement. This means that there is a characteristic period of in-

creased tonsillar activity at the onset of senescence corresponding to the similar period before puberty.

Many difficulties in advanced age may be ascribed to the tonsils. With the recognition of their presence even in the highest age groups, preventive geriatrics should observe these organs carefully especially at the threshold of the regressive years.

414 BEACON STREET.

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## Abstracts of Current Articles

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### EAR

#### **Penicillin In Acute Otitis Media and Mastoiditis—A Report of Cases.**

*Ball, Simon: Arch. Otolaryng.* 41:109 (Feb.) 1945.

The use of penicillin in the treatment of acute otitis media and mastoiditis is becoming more general since the drug has been made available in larger quantities. In reporting the results obtained in the treatment of 12 patients with acute suppurative otitis media complicating scarlet fever, and five patients with nonscarlatinal otitis media and mastoiditis, the author stresses the point that the number is too small to draw any definite conclusions. The work was carefully done, however, and the results have value as a matter of record in our present knowledge of the action of penicillin.

All of the patients had been unsuccessfully treated with adequate doses of sulfonamide compounds. The diagnosis of acute otitis media and acute mastoiditis was established on otologic and roentgenologic evidence. The organisms found on culture of the various aural discharges were *Streptococcus hemolyticus*, *Staphylococcus albus hemolyticus* or *Staphylococcus aureus hemolyticus*.

The penicillin was administered intramuscularly in doses of 20,000 units at four hour intervals. On the postscarlatinal cases the dosage ranged from 860,000 Oxford units over a period of seven days to 2,850,000 Oxford units over a period of 21 days. The average length of time being ten days. One mastoidectomy was performed with recovery. In the five nonscarlatinal cases the dosage ranged from 380,000 Oxford units over a period of four days to 2,000,000 Oxford units over a period of 18 days, the average length of time being 7.4 days.

In all cases the discharge had stopped, the perforation had healed, complete restoration of hearing had taken place and the patient had gone on to clinical recovery.

McMAHON.

**Hearing in a Dog After the Removal of the Tympanic Membrane and Malleus on Both Sides.**

Grobbehaar, C. S., and Keen, J. A.: *J. Cape Town Post-Grad. M. Assn.* 3:346 (Sept.) 1944.

In questioning the validity of the Helmholtz theory of sound conduction, the authors advance the following objections: (1) Mechanical: The chain of three ossicles, complicated by two joints, and further hampered by the attachments of two muscles, is badly adapted for sound conduction from one membrane to another. (2) Clinical: A number of cases are on record of fairly good hearing despite the absence of the middle ear structures following radical mastoid operations. (3) Morphological: In a recent study by these authors of the tympanic bulla and ossicles the problem of sound conduction is approached from the standpoint of comparative anatomy, and all the evidence is against the classical Helmholtz theory.

Their experiment consisted of removing the tympanic membranes and mallei from the middle ears of a dog at an interval of one month, in order to theoretically break the membrano-ossicular chain. Tests were then made upon the hearing of the dog in whom a conditioned reflex to certain sounds had been established preoperatively. The dog was found not to respond to a previously recognizable sound (the ringing of a bell) for the first ten days following each operation. After that time the response was similar to that of the preoperative period of observation. Two months after the last operation the dog was permitted to range, and reacted like all other dogs to the usual sounds, including learning to bark in response to the barking of other dogs, her behaviour being in every way that of a dog with good hearing. As a result of their experiment, the authors argue that the classical Helmholtz theory of sound conduction should be abandoned in favor of certain alternative hypotheses.

McMAHON.

**MISCELLANEOUS****Chemotherapy In Otolaryngology.**

Williams, Henry L.: *Wisconsin M. J.* 44:507-511 (May) 1945.

In the use of chemotherapy in general, Williams proposes three principles for general guidance.

First, since the chemotherapeutic agents now available are only active against the gram-positive cocci and bacilli, the causative organism should be determined before potentially dangerous drugs are



administered, except in such conditions where the gravity of the infection outweighs the danger of the drug.

Second, in mild infections, such as the common cold where the incidence of complications has been estimated at about 1 in 1000, a drug capable of producing more frequent and serious complications in itself should not be employed.

Third, if the drug is used at all the dose should be adequate to produce the desired effect. The usual dosage is roughly 1 grain of the drug to every pound of body weight per 24 hours, with an initial dose of  $1/3$  to  $1/2$  of the estimated 24 hour total. In mastoiditis and otitic meningitis, a blood concentration of the usual sulfonamide drugs used should be maintained at 15 to 20 mg. per 100 cc. of blood. Because of the rapid excretion of the drug it should be given at regular intervals around the clock and the practice of giving the drug during the daytime only should be deprecated.

The presence of para-amino-benzoic acid, which substance collects in high concentration in pus pockets, inhibits the activity of the sulfonamide drugs and because of the lack of vascularity of necrotic areas, they can often not reach the infected area. Therefore in any case in which the sulfonamide compounds or penicillin are to be used, collections of pus should be drained and necrotic tissue and bone removed.

Sulfadiazine is recommended as the sulfonamide of choice for almost all infections. Because, of all sulfonamide compounds, it is the least soluble in water and therefore the most likely to precipitate in the urinary tubules, fluids should be forced during its administration and the urine should be kept at a pH of 8 to 9.5. This can be accomplished by the administration of 20 grains of sodium bicarbonate every four hours.

With penicillin there is no evidence that any toxic reaction is produced. Because it maintains a more constant blood level and produces effective clinical results with a smaller dose, the best method of administration is the continuous intravenous drip, originally described by Herrell and associates. Forty thousand Oxford units are dissolved in one liter of isotonic salt solution or in a five per cent solution of dextrose in triple distilled water. Initially 200 cc. of this solution are administered at a fairly rapid rate. Thereafter the rate of administration is regulated to about 35 drops per minute. Penicillin may be administered intramuscularly into the gluteal region, using 10,000 to 20,000 units dissolved in 2 to 4 cc. of isotonic salt

solution every three hours. In William's experience, twice as much penicillin is required intramuscularly as intravenously to produce a comparable clinical result.

Commenting on the local use of chemotherapeutic agents, Williams has not found the use of a five per cent solution of sulfathiazole in the nose, as advocated by Turnbull, of any benefit in the treatment of chronic and subacute sinusitis. He has given the treatment of sinusitis with solutions of gramicidin, tyrothricin and penicillin by means of the Proetz displacement technic considerable trial and is very much disappointed in the results.

In cases of acute sinusitis, acute otitis media and acute mastoiditis, the oral administration of chemotherapeutic agents may be of value in the stage of engorgement before the purulent foci are created. After this has taken place, the pus must be drained and the necrotic tissue removed, after which the sulfonamide may be continued as an adjunct. In both acute sinusitis and acute otitis media the use of a sulfonamide compound may modify the course of the disease, which modification has led to the discussion of the so-called "masking" effect of the drug. In his opinion "masking" is only the incomplete eradication of the disease and should not present any particular problem to one familiar with the usual clinical course of sinusitis, otitis or mastoiditis.

In osteomyelitis of the cranial bones, secondary to sinusitis, the use of the sulfonamide compounds produces a false sense of security rather than a curative effect. He believes that chemotherapeutic agents are, therefore, contraindicated in this condition.

In cases of spreading osteomyelitis of the frontal bone, Williams has found penicillin of special importance. The micro-aerophilic and anaerobic organisms, which have been demonstrated as the primary organisms in this condition, are resistant to sulfonamide compounds but respond to penicillin very well. Therefore, Williams believes that the treatment of acute fulminating frontal sinusitis should begin with a trephine opening into the floor of the frontal sinuses to avoid opening into cancellous tissue, followed by irrigations with some solution like hydrogen peroxide, to establish aerobic conditions within the sinus, together with the use of penicillin. All pockets of pus must be drained and all the necrotic bone must be removed. With penicillin therapy this may be done through a coronal incision which may be closed with superficial drainage only. This form of treatment avoids the open dressing of wounds and everted skin flaps which conditions later require multiple plastic operations for closure.

In cases of otitic meningitis, because of the failure of penicillin to penetrate the hemato-encephalic barrier, Williams believes that it should be given intrathecally in doses of 10,000 Oxford units dissolved in 2 cc. of sodium chloride solution, combined with adequate doses of sulfadiazine. After the patient has made an apparent recovery, small doses of sulfadiazine should be continued for ten days to prevent, if possible, a recurrence of the infection.

GROVE.

**Carcinoma of the Cheek, Alveolar Process, Floor of Mouth, and Palate.**

*Beiswanger, R. H., and Stenstrom, W. K.: Radiology 44:213-225 (March) 1945.*

One hundred sixty cases during 1926 to 1940 are reviewed, 129 were confirmed as carcinoma by biopsy. The cases were divided into six clinical groups according to the location of the primary growth and into four stages according to the extent of the involvement. Radiation alone or radiation and surgery combined controlled 61 per cent of stage II and 60 per cent of stage III cases. The five year survival rate of the whole group was 24 per cent. Etiology, symptomatology, differential diagnosis, metastasis, treatment and complications are discussed. The results of treatment in each clinical group with positive biopsy are discussed in some detail.

JORSTAD.

## Notices

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### AMERICAN BOARD OF OTOLARYNGOLOGY

The American Board of Otolaryngology will conduct an examination on October 3-6, 1945, at the Palmer House, Chicago. All communications should be addressed to the secretary, Dr. Dean M. Lierle, University Hospital, Iowa City, Iowa.

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### UNIVERSITY OF ILLINOIS COLLEGE OF MEDICINE REFRESHER COURSE

The University of Illinois College of Medicine announces its sixth semi-annual "Refresher" Course in Laryngology, Rhinology and Otology, September 24th through September 29th, 1945, at the College, in Chicago. The course is largely didactic, but some clinical instruction is also provided. For information apply to Dr. A. R. Hollender, Department of Otolaryngology, University of Illinois College of Medicine, 1853 West Polk Street, Chicago 12, Illinois.

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